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# PLUMBING AND PUBLIC HEALTH

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# PLUMBING AND PUBLIC HEALTH

By

ARTHUR B. CRONKRIGHT, Project Supervisor
and
ARTHUR P. MILLER, Sanitary Engineer
U. S. Public Health Service

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## CONTENTS

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## LIST OF TABLES

CHAPTER V



LIST OF FIGURES

CHAPTER I



CHAPTER III



CHAPTER IV



CHAPTER VI

CHAPTER V



LIST OF FIGURES

CHAPTER I



CHAPTER III



CHAPTER IV



CHAPTER VI

# PLUMBING AND PUBLIC HEALTH

## INTRODUCTION

That phase of plumbing having to do with the supplying and using of water has in the past few years assumed an increasing importance in its relation to public health. For the past few decades the ratio of urban to rural population has been steadily increasing and with this influx of people to the cities has come a corresponding increase in the complexities met with in supplying a safe and pure drinking water. The introduction of the sand filter and of chlorine as a disinfecting and sterilizing agent has resulted in a definite and commendable decrease in the number of cases of water-borne diseases. It was not until recently, however, that the development of spontaneous and sporadic outbreaks of these diseases awakened health and waterworks officials to a realization that something besides the protection of the source of water supply and the delivery of pure water to conduits was necessary in order to protect the health of the public. Various decisions of the courts have held the water company or the municipality responsible for the delivery of safe water to the consumers. These decisions aided in focusing attention on the possibility of contaminating the water through cross-connections with secondary supplies of water. The demonstrating of such a possibility and the tracing of the cause of several outbreaks of disease to such connections resulted in a concerted effort on the part of health and water-works officials to eliminate and control these hazards.

The step from the realization of the dangers of cross-connections to the belief that the existence of faulty and defective plumbing in a building might cause, under similar conditions, a disastrous effect on the quality of the water supply or on the health of the public was a natural but slow one. A few scattered outbreaks of water-borne diseases were shown to be the result of the existence of such conditions, and this resulted in arousing the interest of several individuals and organizations to the danger of such installations. It was not, however, until the outbreak of amebic dysentery in two hotels in Chicago in 1933 [1] that health and water-works officials and the plumbing industry

Submitted for publication July 1, 1938.

[1] "Water-borne Outbreaks in the United States and Canada 1930–36 and their Significance." American Public Health Association Yearbook, 1937–38, p. 137.

in general realized the inherent hazards of defective and poorly designed plumbing fixtures and installations. That epidemic, resulting in 1,409 cases and 98 deaths, was attributed to the existence of old and faulty piping and to a poorly designed plumbing system. The widespread publicity attending this outbreak enabled the facts of the epidemic to be brought before a large number of persons affiliated with this subject and caused a renewal of interest which has been productive of much good since then.

This study was designed to have three major objectives. The first was to bring together under one cover all the information on this subject which it was possible to secure. This should be helpful to the many persons who are now intensely interested in this public health problem. The second was to amplify the summary of the project which involved the inspection of plumbing in New York City and Detroit Federal buildings (*250*) in such a way that the technique used would be available to others and that improvements in the methods employed could be pointed out. The third objective was to focus attention on this subject and to emphasize the importance of approaching it with an open mind and in a conservative, well-balanced, and rational way. That interconnections in plumbing may present a hazard to public health cannot be denied, but the determination of the degree of hazard in the buildings in any locality is of the utmost importance before public officials divert time and money to corrective measures.

The authors wish, at this time, to gratefully acknowledge the assistance given by all public officials, company officers and individuals who so kindly responded to our requests for data. Without their cooperation, this study could not have been made so complete.

# CHAPTER I

## WATER-BORNE DISEASES. DEFINITION OF TERMS. DESCRIPTION OF PLUMBING HAZARDS

### Water-Borne Diseases

Water has for many years been established as a medium for the spread and transmission of disease organisms. Among the first and most noted outbreaks of disease, the spread and transmission of which were associated with water, are: the outbreak of Asiatic cholera in London in 1854;[2] the epidemic of typhoid fever in Plymouth (Pennsylvania) in 1885;[3] and the outbreak of Asiatic cholera in Hamburg, Germany, in 1892.[4]

There are a number of diseases which may be spread through the medium of water either by contaminating the drinking-water supply or through the overcrowding and inadequate control of swimming pools or bathing places. The latter means of spreading infections and disease-producing organisms has received considerable attention of late and numerous regulations controlling the operation and use of swimming pools and bathing places have been promulgated and enforced. Previous to the enforcement of these regulations and the development of an adequate control of the water in these pools, it was possible to spread eye-and-ear, respiratory, and intestinal diseases by this means.

The prevalance of epidemics of disease spread through the contamination of the domestic water supply has been reported by Wolman and Gorman in their study of water-borne typhoid fever outbreaks of 1920–30[5] and in a subsequent report covering the years 1930–36.[6] These reports discuss and classify all outbreaks of water-borne diseases affecting more than five persons as to cause, method of spread, and severity. In the first report, no classification

[2] "On the Mode of Communication of Cholera." Report on Cholera Outbreak in the Parish of St. James, Westminster, During the Autumn of 1854. Presented to the Vestry by the Cholera Inquiry Committee. J. Churchill, London, 1855, 162 pp.

[3] "First Annual Report, State Board of Health and Vital Statistics of Pennsylvania." Harrisburg, Pa., 1886, p. 176–195.

[4] Rosenau, M. J. "Preventive Medicine and Hygiene." 5th Edition. D. Appleton and Co., New York and London, p. 1058 (1927).

[5] Wolman, A., and Gorman, A. E. "The Significance of Water-borne Typhoid Fever Outbreaks, 1920–30." Williams and Wilkins Co., Baltimore, Md. (1931).

[6] Water-borne Outbreaks in the United States and Canada, 1930–36, and Their Significance." American Public Health Association Yearbook, 1937–38, p. 137.

was made for the minor gastrointestinal disturbances that appear to be of epidemic character. Outbreaks of this nature were classified under the heading of dysentery. In the later report, however, the dysenteries are separated from the minor intestinal disturbances and the latter are grouped under the heading of diarrhea.

Table I lists a number of diseases which may be spread through contamination of the domestic water supply together with their etiological agent, mode of transmission, and prevalence. Water-borne jaundice has been omitted from this list pending further information as to the causative agent and the prevalence of the disease. Of the various diseases listed in table I the most important from a health standpoint, at least in this country, are typhoid and paratyphoid fevers, the dysenteries, hookworm, and diarrhea. The incidence of the other diseases listed is very small.

**Table I.[1]—*Water-borne diseases***

| Disease | Etiological agent | Mode of transmission | Prevalence |
|---|---|---|---|
| Ancylostomiasis (hookworm disease). | Necator americanus and rarely Ancylostoma duodenale. | Contaminated soil, water containing larvae, soiled food, hand to mouth transmission from handling soiled objects. | Endemic in Southern States particularly among white children of school age. |
| Cholera | Cholera vibrio, Vibrio comma. | By water and food polluted by infectious agent; direct contact, carriers, flies, and contact with articles freshly soiled by discharges of infected persons or carriers. | Rare in North America. |
| Dysentery, Amebic (Amebiasis). | Endamoeba histolytica | By drinking contaminated water, by eating infected food, hand to mouth transfer of infected material. | Not common in North America, epidemic outbreaks rare. |
| Dysentery, Bacillary. | Dysentery bacillus, Shigella dysenteriae, Shigella para-dysenteriae. | Eating infected food, hand to mouth transfer of infected material; flies, objects soiled with discharges of infected persons or carriers, drinking polluted water. | Endemic, epidemic and sporadic. Most common in summer months and in subtropical and tropical areas. |
| Typhoid fever | Typhoid bacillus, Eberthella typhi. | Conveyance of the specific micro-organism by direct or indirect contact with a source of infection. Among indirect means of transmission are contaminated water, milk, and shellfish and probably flies. | Occurs sporadically and as small contact and carrier epidemics, endemic in small southern rural areas. |
| Paratyphoid fever | Paratyphoid bacillus A, B, or C; Salmonella paratyphi; Salmonella schottmüelleri. | Directly by personal contact, indirectly by contact with articles freshly soiled by the discharges of infected persons or through milk, water, or food contaminated by such discharges, probably by flies. | Relatively rare, occurs sporadically or in small local carrier or contact epidemics. |
| Schistosomiasis (flukes). | Animal parasites of the class Trematoda, genus Schistosoma; S. japonicum, S. hematobium, S. manson. | Ova hatch in water and enter mollusk, genus Planorbis in the West Indies, in the mollusk they multiply and develop into larval forms called "cercariae", which on leaving the mollusk penetrate the skin of man and certain animals. | Not indigenous in the United States at present. |
| Diarrhea | A number of specific organisms suspected, among which are the coli-aerogenes group bacteria. | Polluted water and other causes not known. | Universal, epidemic, endemic, and sporadic. |

[1] American Public Health Association. Report of the Subcommittee on Communicable Diseases Control, of the Committee on Research and Standards. "The Control of Communicable Diseases." Public Health Reports, 50:1017 (Aug. 9, 1935).

By referring to the two reports on the significance of water-borne disease outbreaks already mentioned, it can be seen that the cause of over 50 percent of the outbreaks was the use of untreated surface or ground water that had in some manner become infected. It is interesting to note, however, that slightly over 10 percent of the outbreaks occurring from 1920 to 1937 in this country were due to contamination of the water in the distribution system and that in the majority of these cases contamination had reached the systems through the existence of cross-connections with auxiliary sources of water. No classification was made in the reports to indicate the type of cross-connections responsible for the various outbreaks.

In an effort to determine the number of outbreaks of water-borne diseases that could be attributed to the existence of defective and poorly designed plumbing in buildings, a questionnaire was sent to 130 State and municipal health officers. Excepting the Chicago epidemic of amebic dysentery, only 3 outbreaks of illness, including 1 of lead poisoning, were reported as having any relation to the existence of faulty plumbing in buildings. These are tabulated in table II.

**Table II.**—*Outbreaks of illness attributed to the presence of interconnections*

| Location | Type of building | Number of cases of illness | Type of illness | Cause of outbreak or general remarks |
|---|---|---|---|---|
| Marion County, Ind. | Convent | 30 | Typhoid fever | Interconnection between frostproof water closet and well water distributing system permitted backflow of sewage into system. |
| St. Paul Minn. | Laundry | Several | Typhoid fever | Drinking fountain installed in such a manner that the drainage from it returned to the water supply tank. Original infection presumed to have been introduced by means of soiled laundry. |
| Baltimore, Md [1] | Industrial plant. | 2 | Lead poisoning | Direct connection between the domestic water supply and a pump used to pump a highly poisonous lead compound. The connection was made for the purpose of priming the pump. |

[1] See Bibliography, No. *66*.

The lack of more authenticated cases of disease outbreaks from this cause should not result in minimizing the dangers inherent in such connections and installations. It is extremely difficult in many cases to find and designate a particular plumbing hazard as the cause of an outbreak. The combination of circumstances under which a water supply may become contaminated may not be apparent. The extended incubation periods of the various diseases may result in the development of the outbreak after the condition producing the contamination of the water has been removed or corrected. Also, in the case of small outbreaks of disease, adequate investigation may not be resorted to for determining their causes. A thorough

investigation into the cause of each case of disease that may be water-borne, especially typhoid fever and the dysenteries, might result in the correlation of many of these scattered outbreaks with the existence of faulty and defective plumbing. Until a more widespread interest is aroused in this subject and a more thorough study is made of all cases of water-borne diseases, whether of epidemic proportions or not, the extent to which plumbing defects are responsible for the spread and transmission of infections will not be definitely known.

### Definition of Terms

Before discussing and explaining the various types of plumbing defects by which the water supply may become contaminated, it is necessary to define the various terms to be used throughout this discussion. The several investigators in this field each use a terminology peculiar to themselves and this impedes a profitable comparison of their work.

*Cross-connections.*—The definition of the term "cross-connection," except in quoted material, coincides with the definition given in a report of the committee on cross-connections of the New England Water Works Association,[7] which is: "* * * a connection between the distribution system of a public or private, potable water supply and a private or secondary, nonpotable supply."

The terms "private or secondary, nonpotable supply" shall be taken to indicate a supply of water, for either industrial, fire, auxiliary, or other purposes and shall in no sense be taken to mean waste material, sewerage systems, or the like.

*Interconnection.*—Whereas a cross-connection represents an installation between two water supplies, there are often many connections to the water distribution system, outside and inside of buildings, involving no private or secondary, nonpotable supply, through which the potable supply may become contaminated.

Therefore, any connection to the distribution system of a public or private potable water supply, other than one with a private or secondary nonpotable supply through which contamination may enter the potable water-supply lines, shall be known as an interconnection.

*Back-siphonage.*—The phenomenon characterized by a reversal of flow in a plumbing system, fixture or appliance and caused by the development of a less-than-atmospheric pressure in the supply line to the installation is back-siphonage.

*Vacuum.*—An absolute pressure of less than 1 atmosphere (14.7 lb/sq. in. at sea level) shall be termed a vacuum. (Exception to this definition is made in chapter IV for specific reasons given there.)

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[7] Report of the Committee on Cross-connections. Journal of the New England Water Works Association, 43 : 1 : 79 (March 1929).

*Submerged inlet.*—Any unrestricted water-supply connection or inlet to a plumbing fixture, appliance, or installation, other than a direct enclosed connection, which is located a distance of less than $2D$ or $2\frac{1}{4}\sqrt{A}$ above the highest possible water level of the fixture, appliance, or installation, where $D$ is the diameter of the inlet, if circular, and $A$ is the area of the inlet, if other than circular, shall be known as a submerged inlet. (*139*)

*Highest possible water level.*—The highest point to which water may rise in a fixture should the drain from the fixture become clogged shall be known as the highest possible water level of that fixture.

### Description of Plumbing Hazards

Contamination of the water supply by means of interconnections or defective plumbing fixtures may take place: (1) by the occurrence of a vacuum in the supply pipes causing back-siphonage of contaminated material, (2) by the development of a pressure in the fixture, appliance, or piping system to which the water supply is connected that is greater than that in the supply system itself, and (3) through the activities or actions of vermin, birds, or small animals in parts of the supply system not under pressure, or by dust reaching water-holding devices.

A list of fixtures that might be considered hazardous to health would be very long. The development of various mechanical devices and appliances in which water is used as a primary or secondary function of the operation of the machine and the numerous industrial uses to which water is put have resulted in an exceedingly large number of different types of fixtures and plumbing appliances, some safe and others hazardous. Describing the most common fixtures in use today that may be considered as health hazards will suffice to illustrate, in all except a few instances, the essential features of a defective fixture or installation. Figures 1 to 6 illustrate the most common types of fixtures encountered.

*Flush valve.*—A very common interconnection which has been given too little attention in past years involves the simple flush valve on the siphon-jet type fixture.

Satisfactory mechanical operation of most flush valves depends upon the maintenance of a continuous positive pressure in the water-supply lines. Should a vacuum occur in the supply line, the flush valve may open and back-siphon the fixture contents through the siphon-jet opening. It is not necessary for a siphon-jet fixture to be stopped-up in order for back-siphonage to occur. Even should the flush valve not open, a leaking valve would permit contaminating liquid or material to pass back through it.

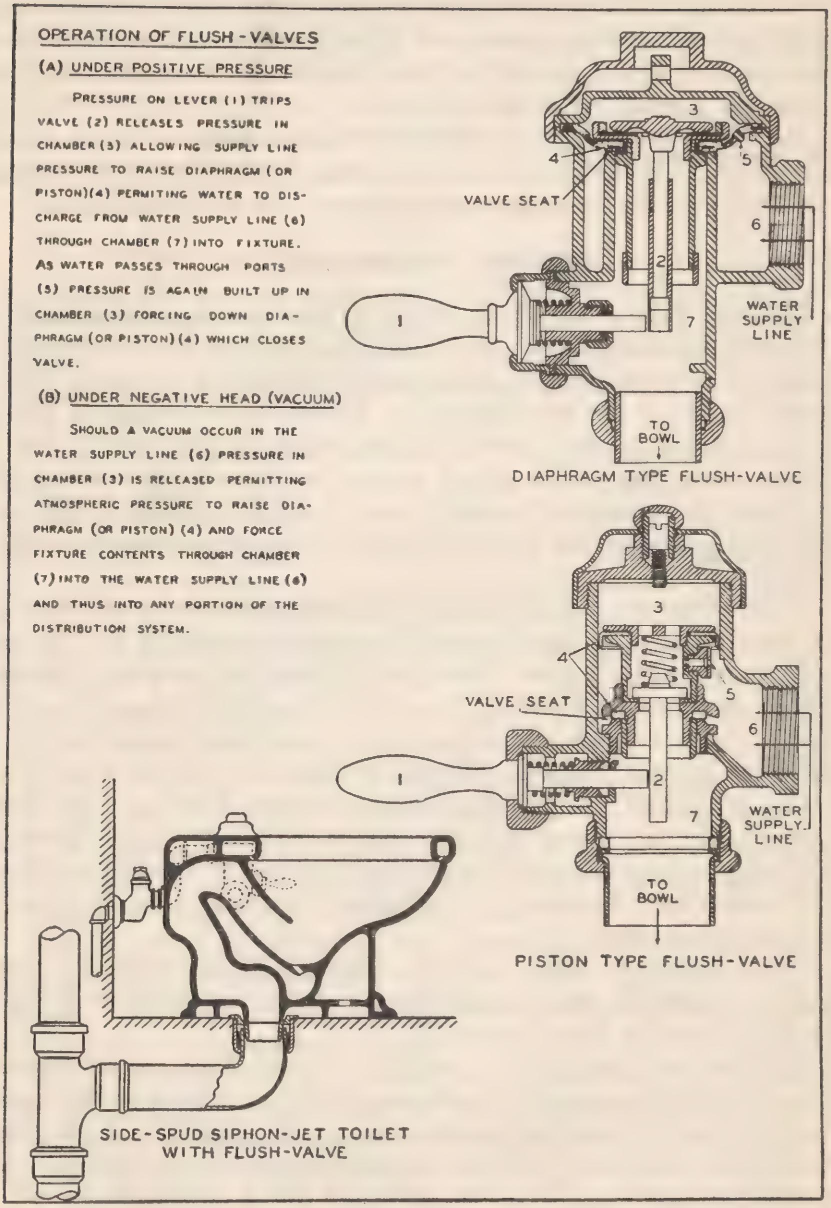


FIGURE 1.—Flush valves.

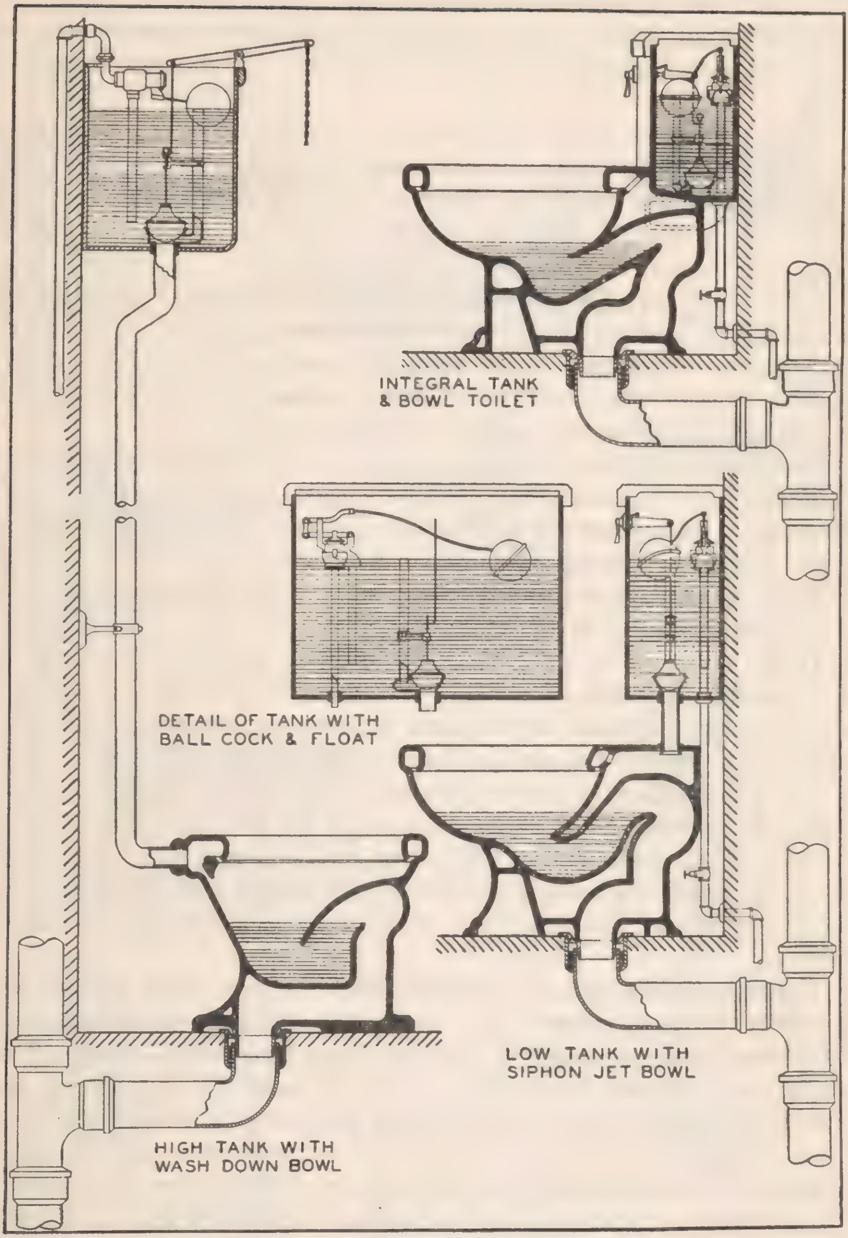


FIGURE 2.—Flush tanks.

*Flush tanks.*—To insure quietness of operation the inlets to flush tanks are almost always submerged. If the ball cock leaks or if it is opened for the purpose of filling the tank during a period of vacuum in the supply line, a portion of the tank contents may be back-siphoned carrying with it any pollution which may be in the tank.

There are three types of flush tanks in general use for toilets: (1) the tank built integral with the toilet bowl, (2) the low tank, separate from the bowl, the outlet of which is usually two or more inches above the top of the bowl, and (3) the high tanks, most often used with a wash-down bowl.

With the integral tank there is so little difference in elevation of water in the tank and bowl that only partial stoppage in the latter will permit a mixture of the bowl and tank water. Such fixtures should therefore be considered deficient unless the tank-water inlets are adequately protected against back-siphonage.

Low tanks are also subject to pollution by a mixture of the bowl contents with the tank water. For example, if a bowl stoppage occurs and a rubber force pump is used, a portion of the bowl contents may be injected through the siphon jet openings into the tank. The polluted tank contents are then subject to back-siphonage through the submerged inlet in the tank.

If the cover of an integral or low tank is airtight, or nearly so, it is possible for the bowl contents to be drawn from the bowl through the tank into the water supply lines, if the tank inlet orifices are submerged or unprotected against back-siphonage.

The possibilities of back-siphonage from a high tank to supply lines are quite as great as in the case of the low and integral type tanks. High tanks are usually open and consequently are subject to air pollution but other possibilities of contamination exist, such as by vermin or leakage from pipes passing above the uncovered tanks.

*Lavatories, bathtubs, and laundry trays.*—These three fixtures are common to almost every home. A large percentage of them, as will be shown later, are supplied through submerged inlets. Most all of these fixtures have an overflow outlet at some distance below the rim, but so many conditions may occur to render this overflow useless that is should not be considered as a protection against back-siphonage. For example, in almost every installation of this type the overflow is connected into the drain line of the fixture at a point before the trap. Should the drain line become plugged beyond this connection it would render both the drain line and the overflow useless as a means of disposing of the water in the fixture. Under such conditions it is entirely possible to cause the water to rise at least up to the spill line of the fixture thereby submerging the inlet.

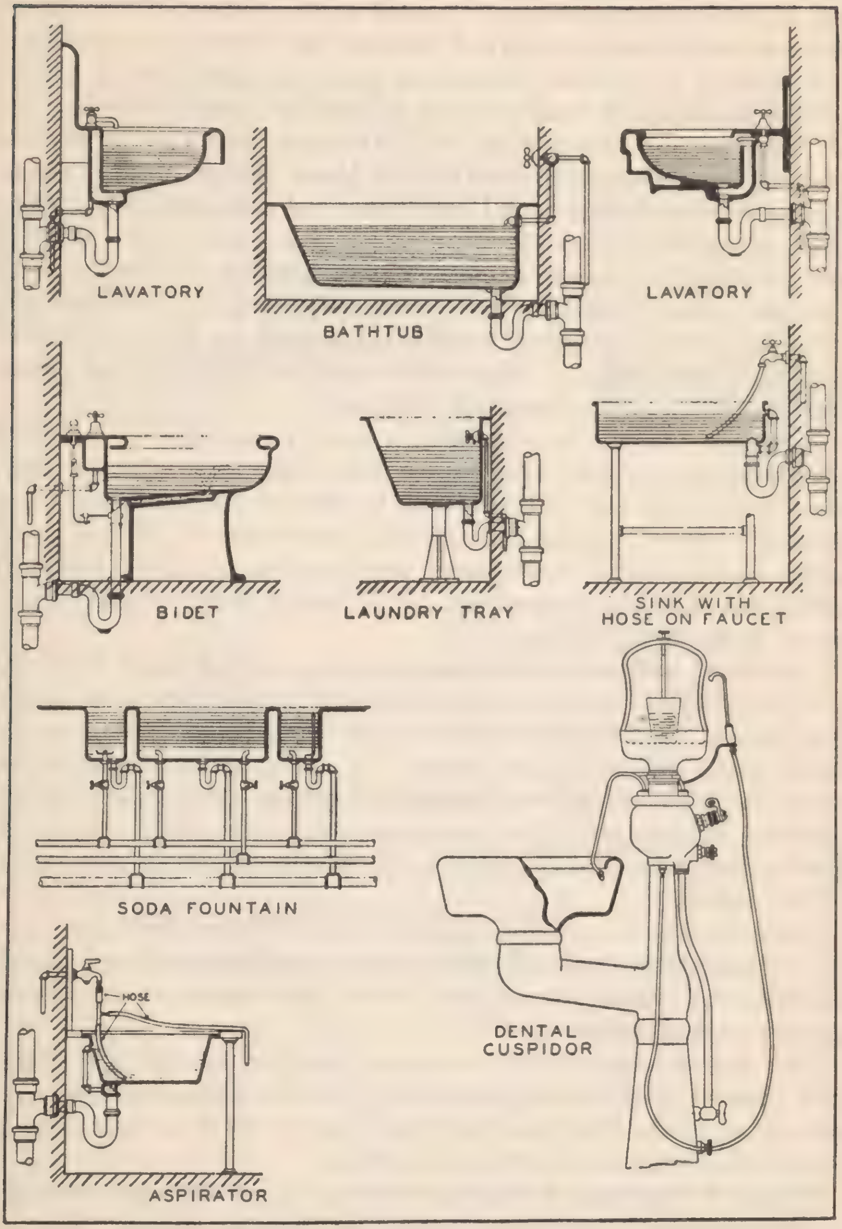


FIGURE 3.—Other plumbing fixtures.

*Other common plumbing fixtures.*—Soda fountain sinks, bidets, aspirators, and dental cuspidors present more hazards than most of the fixtures with submerged inlets. As the inlets to soda fountain sinks and bidets are most commonly located at the bottom of the fixture, they are continuously submerged whenever the fixture is in operation.

Aspirators are suction pumps, the power of suction being created by the rapid flow of water through a restricted opening at the point of attachment of the suction line. They are used to remove fluid contents of tumors and collections of blood during surgical operations and saliva during dental operations, and as ejectors in handling fluids in chemical laboratories and waste wash water from washtrays and washing machines in homes. The principle is the same in each case and unless protection against back-siphonage is provided it is possible, when the discharge outlet is submerged, for contamination to reach the water supply. The dental cuspidor in figure 3 is a particular application of the aspirator principle.

A very commonly found defect is usually man-made. It is best illustrated by the sink with an overflow outlet and a faucet, above the rim overflow line of the fixture, to which a short length of hose leading to the bottom of the sink has been attached. X-ray photograph and blueprint development trays, and arm and leg baths are variations of the same hook-up. It is also a defect almost always found in an autopsy room.

*Industrial equipment.*—The application and use of water for industrial purposes has created a large number of different types of plumbing fixtures. Among the most common of these appliances are the laundry and dishwashing machines. In almost all of these installations, the inlets are either submerged or become submerged when the machine is operated. The occurrence of a vacuum in the supply lines to these fixtures may cause back-siphonage of part of the contents of the devices.

*Hospital fixtures.*—Bedpan washers and sterilizers may have a portion of their contents drawn into the water-supply line when a vacuum exists in the latter provided the inlet to the fixture is not protected against back-siphonage.

The defects encountered in various sterilizer set-ups are similar and Figure 6 illustrates, hypothetically, the ones most often seen. The defects shown in this figure have been assembled from real installations in everyday use in several hospitals.

Figure 6 represents a sterilizer hook-up in about the worst light although other defects were found which are not shown. The fixtures illustrated are in many cases old models and now out of date. The more modern hospital equipment has many improvements over the old, although some of the most modern pieces of equipment still

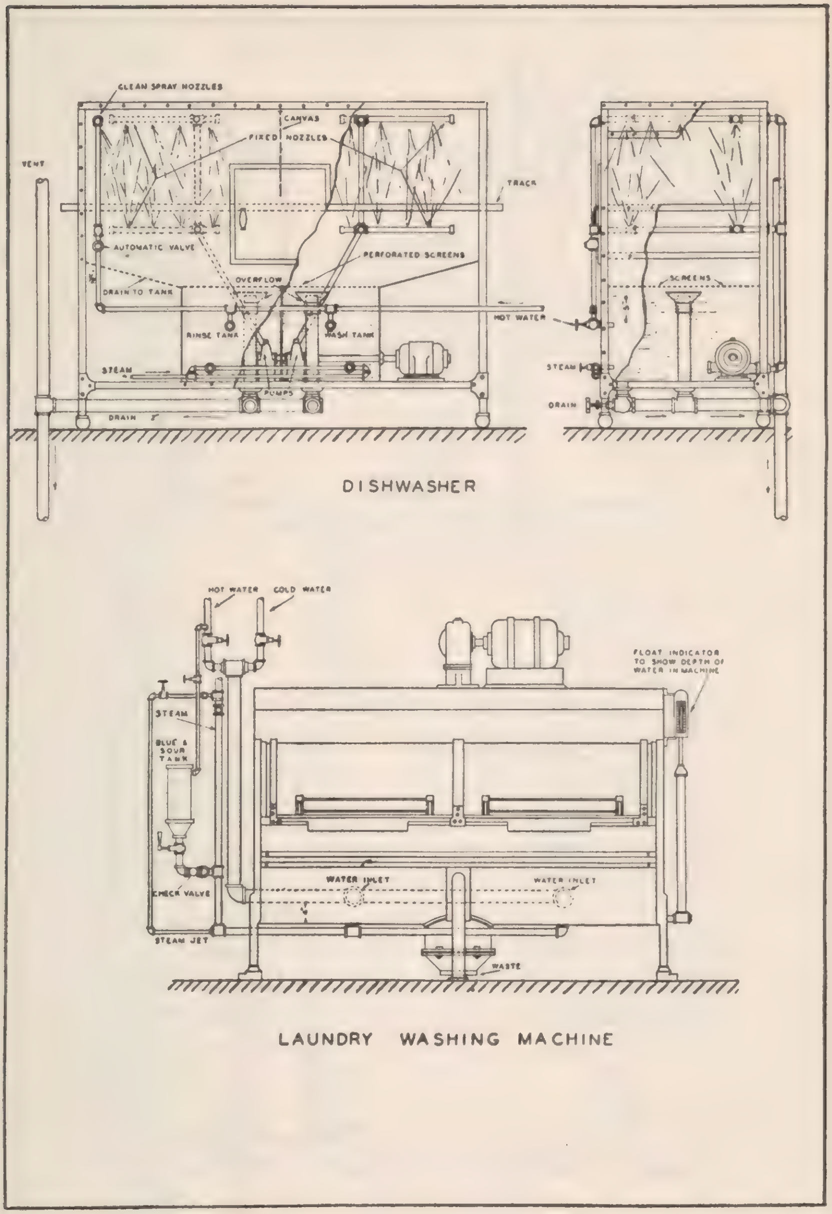


FIGURE 4.—Dishwasher and laundry washing machine.

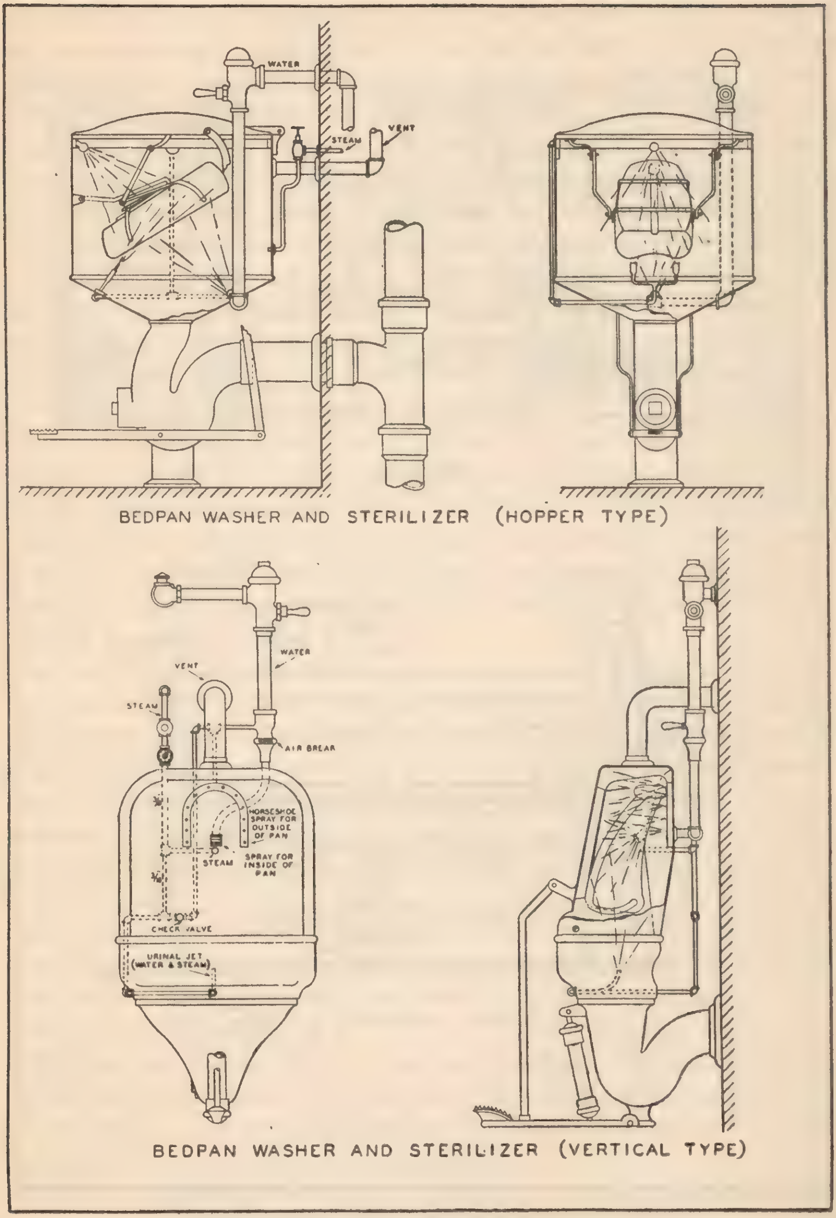


FIGURE 5.—Bedpan washer and sterilizer.

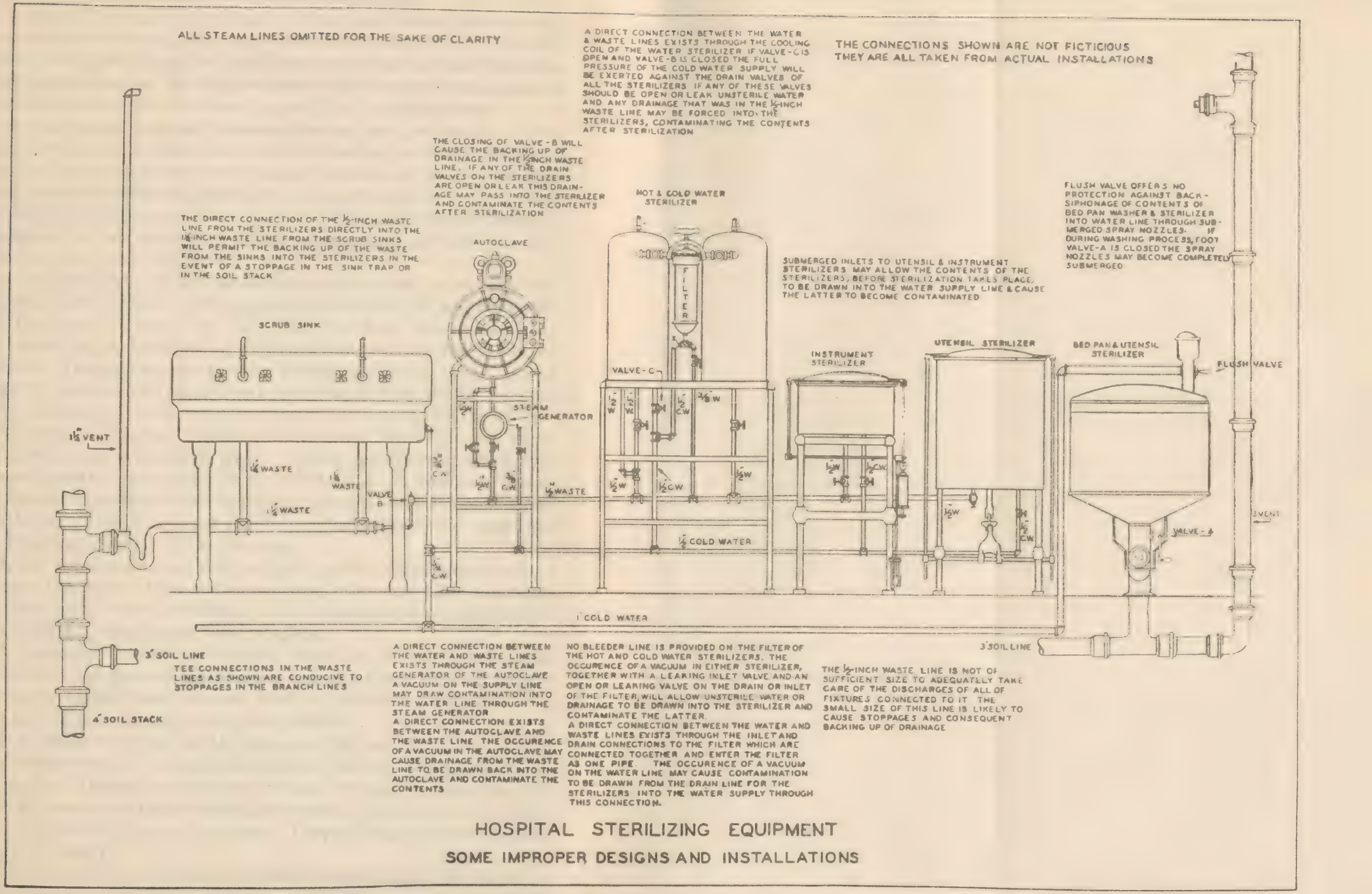


FIGURE 6.—Hospital sterilizing equipment.

have defects due to improper installation or to the design of the fixture itself. Some of these are discussed briefly here.

1. *Improper design of equipment.*—This may include the omission of a means of draining the gage glass and the tap of a water sterilizer. If either of these two places contains nonsterile water after the sterilization process, the finished water may become recontaminated through contact with this small quantity of nonsterile water.

2. *Improperly designed vacuum breakers and air-breaks.*—These may include (*a*) vacuum breakers with moving parts that are actuated only by the formation of a vacuum in the water line, (*b*) air gaps and vacuum breakers of insufficient size to furnish the air necessary to dissipate the vacuum, and (*c*) air breaks and vacuum breakers designed for use on high-pressure systems and installed on low-pressure lines, and vice versa.

3. *Bleeder lines, drains and overflows submerged or directly connected to waste lines.*—Certain types of sterilizers are equipped with air breaks on the waste line. The drain line from the sterilizer may be submerged in the funnel or connected into the waste line below the funnel. The same may be true for bleeder or overflow lines. In any case, the purpose of the air break is defeated if any of the lines are submerged in the funnel or are connected to the waste line below it.

4. *Direct connection of cooling coil to waste line.*—The cold water sterilizing unit is equipped with a cooling coil through which cold water passes to cool the water after sterilization. A number of installations have this line connected directly into the waste line without an air break. This is a direct interconnection between the waste line and the water supply of the building.

5. *No bleeder line on filter or inlet valve.*—The omission of a bleeder line from a filter or from an inlet valve may allow nonsterile water to pass into the sterilizer and contaminate the contents after the sterilizing process has been completed.

6. *Improper location of vacuum breakers and air breaks with respect to the fixture.*—Insufficient height of the vacuum breaker above the highest possible water level in the fixture may cause even the best vacuum breaker to become ineffective.

7. *Changes in design of the fixture.*—The use of modern fixtures and connections is no assurance against defects of installation and operation. Inspections of hospitals have revealed vacuum breakers and air breaks on the sterilizing equipment which have been taped over to prevent noise and spitting. Proper design should forestall this eventuality.

*Miscellaneous.*—The fixtures already described and illustrated are characterized by the fact that the important defect in practically all of them is the possibility of back-siphonage taking place result-

ing in the contamination of the water supply. There are only a few fixtures in which contamination and disease may be spread without occurrence of a vacuum. Foremost among these is the drinking fountain. A joint report of the committee on plumbing of the American Public Health Association and the conference of State sanitary engineers (*57*) outlines the essential factors necessary for the construction of a safe, sanitary drinking fountain which are as follows:

1. The fountain should be constructed of impervious material, such as vitreous china, porcelain, enameled cast iron, other metals, or stoneware.
2. The jet of the fountain should issue from a nozzle of nonoxidizing, impervious material set at an angle from the vertical such as to prevent the return of water in the jet to the orifice or orifices from whence the jet issues. The nozzle and every other opening in the water pipe or conductor leading to the nozzle should be above the edge of the bowl, so that such nozzle or opening will not be flooded in case a drain from the bowl of the fountain becomes clogged.
3. The end of the nozzle should be protected by nonoxidizing guards to prevent the mouth and nose of persons using the fountain from coming into contact with the nozzle. Guards should be so designed that the possibility of transmission of infection by touching the guards is reduced to a minimum.
4. The inclined jet of water issuing from the nozzle should not touch the guard, and thereby cause spattering.
5. The bowl of the fountain should be so designed and proportioned as to be free from corners which would be difficult to clean or which would collect dirt.
6. The bowl should be so proportioned as to prevent unnecessary splashing at a point where the jet falls into the bowl.
7. The drain from the fountain should not have a direct physical connection with a waste pipe, unless the drain is trapped.
8. The water supply pipe should be provided with an adjustable valve fitted with a loose key or an automatic valve permitting the regulation of the rate of flow of water to the fountain so that the valve manipulated by the users of the fountain will merely turn the water on or off.
9. The height of the fountain at the drinking level should be such as to be most convenient to persons utilizing the fountain. The provision of several steplike elevations to the floor at fountains will permit children of various ages to utilize the fountain.
10. The waste opening and pipe should be of sufficient size to carry off the water promptly. The opening should be provided with a strainer.

The use of several types of household filters for the purpose of providing a cleaner supply of drinking water often results in the deterioration of the quality of the delivered water. Unless rigid control is maintained over the cleaning and sterilizing of the filters their use should be discouraged. Reference will be made to the change in the quality of the water passing through such filters in a later chapter.

Another source of contamination is through the improper location of soil and waste pipes with respect to water storage tanks and food handling and ice manufacturing equipment. The location of a soil

or waste pipe over a water storage or supply tank makes possible the spread of contamination by leakage from defective pipes dropping into the tanks. The dropping of any of this contaminating material on food or food handling equipment will have the same effect. In ice manufacturing plants, the improper location of soil and waste pipes above the floor on which the water is frozen may permit leakage to drop into the ice cans and contaminate the ice.

The use of open-top water supply and storage tanks is conducive to the entrance of dust and vermin with a resultant contamination of the water supply.

Another fixture defect that has been brought to the attention of sanitary engineers and health officials recently is the standing waste in bathtubs and lavatories. While the chance for fixtures with this feature to spread contamination and disease is almost insignificant, there remains no justification for its installation and use, as the development of a safe and sanitary device of this type is both possible and economically sound.

# CHAPTER II

## DIGEST OF CORRELATED ACTIVITIES

The activities of health, plumbing, and other organizations in connection with plumbing and public health touch upon several distinct phases of the problem including research, investigations, survey work, and remedial, corrective and preventive measures.

For the publication of results of surveys, investigations, and research, thereby bringing before the plumbing industry, the medical and engineering professions, public health officials and the public at large, the hazards of defective plumbing and interconnections, much credit is due the plumbing trade journals and the several publications of the professional societies. The trade journals of the plumbing industry have been very active in arousing the interest of the national plumbing organizations and the manufacturers of plumbing equipment to the necessity of properly designed and installed fixtures.

Research work in this field has followed varied courses such as the investigation into the prevalence of insanitary and defective plumbing fixtures in use or for sale at any time; the determination of the causes and effects of back-siphonage and vacuum formations and the frequency of vacuum occurrence; a study of the merits of various plumbing fixtures and protective devices and of the factors essential to the proper, safe and sanitary design of plumbing fixtures.

Several individuals and organizations have spent considerable time and effort in research on these problems, and some of them have included, along with their research work, inquiries into the location of plumbing hazards together with proposals for correcting and preventing them.

This chapter has been devoted to a summary of the information available on past and current work in this field. While this résumé was intended to be complete, the authors regret that due to insufficient information it was necessary to omit the results of a few investigations.

The *American Society of Sanitary Engineering* has, for the past 15 years, taken an active interest in the subject of interconnections particularly those related to plumbing fixtures and installations. The proceedings of that organization contain many articles and papers on this subject. These hazards were recognized and remedial meas-

ures and corrective programs were recommended by the society prior to the outbreak of amebiasis in Chicago in 1933.

The *Pasadena Water Department* in 1932 (*251*) made a study of the possibilities of back-siphonage of toilet bowls equipped with flush valves. Results showed that under even small conditions of vacuum it is possible to siphon the contents of a jet-type bowl. Field tests by this department, January to May 1932, on vacuum formations in water mains during periods of shut-off and drainage, indicate that appreciable vacuums will form for extended periods of time, sometimes exceeding 60 minutes. The opening of a fire hydrant to relieve this vacuum does not prevent the formation of a vacuum in the buildings supplied by the water main.

The *Fresno Public Works Department* (*283*) sponsored several field experiments on three school buildings in which flush-valve toilets were located. All fixtures, with the exception of several of the flush-valve toilets, were shut off from the distribution system. These toilets were cleaned and a solution of fluorescin was placed in them. By simulating the conditions under which repair work was done and those existing when a fire occurred in the immediate neighborhood, the contents of the flush bowls were siphoned into the water supply as indicated by the recovery of the dye from other fixtures in various parts of the school buildings and from the street main.

The *National Association of Master Plumbers* has in the last few years evinced a pronounced interest in the subject of back-siphonage and interconnections. In October 1936, the association established a research program at the Institute of Hydraulic Research, State University of Iowa, on the problem of back-siphonage and resultant pollution of the water supply.

The conclusions of this investigation are given below:[8]

1. Vacuum formations in water pipes cannot all be explained by analogy with the action of a simple siphon. Negative pressures in complicated piping systems due to a loss of pressure by friction may be very common.

2. Polluted water from a few submerged inlet fixtures in buildings can pollute the entire piping system in that building, and the pollution may also get back into the street water mains.

3. Vacuums in pipe systems of buildings can be caused by negative water hammer pressure waves, local restrictions in pipes, and condensation of steam in hot-water tanks.

4. The air flow through any given size opening into the pipes in which a partial vacuum exists will reach a maximum value when the vacuum is 15 inches of mercury, and will not become greater with further increase in the degree of vacuum.

5. A separate water supply to submerged inlet fixtures in a building cannot be considered as a practical and adequate elimination of water pollution

[8] Dawson, F. M., and Kalinske, A. A. "Report on Research." Given before the Fifty-fifth Annual Convention of the National Association of Master Plumbers, Atlantic City, N. J., May 24–27, 1937, and by personal communication.

dangers because: first, the cross-connection hazard is enhanced due to the dual water supplies, one safe and the other unsafe; second, it cannot be used for submerged inlet fixtures requiring a pure water supply and also for various hot-water fixtures.

6. Installation of air inlets at tops of water risers and at various other points for purposes of vacuum prevention in water pipes is not the proper solution to the back-siphonage problem because: first, from a pneumatic standpoint entire prevention of partial vacuum formation by this means is practically impossible; second, air inlet devices installed under constant water pressures are entirely undependable.

7. The correct and only solution to the back-siphonage problem is elimination and correction of the individual unsafe fixture. The unsafe fixture is the fundamental evil in the plumbing system that makes back-siphonage possible, and therefore should be the point of attack.

8. Inlets should be raised above the top of the fixture a distance equal to the value from one of the two formulas, $G=2D$ or $G=2\frac{1}{4}$ times the square root of $A$, where $G$ is the gap in inches, $D$ the diameter of water inlet, and $A$ is the minimum area of the inlet. This will prevent any siphonage from such a fixture and will provide a substantial factor of safety. For common types of fixtures, the following heights of gaps are recommended: lavatory, 1 inch; kitchen sink and laundry trays, 1½ inches; bathtub, 2 inches.

9. Under certain conditions, as specified in this report, overflows leading from the fixture to the atmosphere may be considered as determining the maximum possible water level of a fixture, and the water-supply inlet need only be raised above the overflow. However, raising inlets above overflows which connect to the atmosphere, either directly or through an air gap in the overflow pipe, cannot be considered as an ideal solution by any means.

10. The vacuum-breaking principle as defined herein has the necessary requisites for a proper solution to the back-siphonage problem. The proper application of this principle entails rigid requirements relating to the vacuum-breaking device used.

11. It is recommended that the vacuum-breaking principle be accepted as a tentative standard for the proper solution to the back-siphonage problem if the vacuum breakers used meet all requirements specified in this report. It is further suggested that such vacuum-breaking devices, installed on actual installations, be carefully observed for a number of years to note their performance characteristics before they are definitely accepted as standard.

12. The tank closet with the constantly submerged inlet presents as great a back-siphonage hazard as any fixture in the plumbing system. Every effort should be made by manufacturers of closet tanks to have the entire float valve and water-supply piping connections installed above the overflow level of the tank if the tank water is subject to sewage pollution. Unless especially well designed, it is not recommended that moving part vacuum-breaking devices be used in closet tanks because of the corrosive conditions.

13. Automatic flush valve fixtures should be protected from back-siphonage by incorporation of the following items: (*a*) a loose check valve to be incorporated in the stop valve; (*b*) stable unit piston to be used if piston type valve is installed; (*c*) vacuum breaker between the control valve and fixture which meets specified requirements for vacuum breakers; (*d*) no water supply connection to a closet bowl below the flush rim of the bowl should be permitted.

14. The frostproof closet presents such pronounced water-pollution hazards that its use even under the best conditions cannot be considered as satisfactory.

15. A great many hospital fixtures are excellent examples of the water-

pollution hazards that can be introduced in the design of various special fixtures when important sanitary considerations are overlooked.

16. Manufacturers of special water-supply and plumbing equipment and fixtures should be ever alert regarding the introduction into the design of the fixture of back-siphonage hazards. Every attempt should be made to use the best solution to the back-siphonage problem; that is, "inlet above top of fixture."

17. The best program to inaugurate for the elimination of direct cross-connections with auxiliary private water supplies is the eliminating of the wholesale presence of such supplies in buildings served with the public water supply. Only when such auxiliary supplies are reduced to a minimum can regulations and inspections be entirely effective.

18. Direct connection of city water to cooling and condensing systems used in gas compressors, refrigerating apparatus, and air-conditioning equipment should be condemned. Re-use of such water in the domestic supply systems of buildings is not satisfactory from a sanitary viewpoint.

19. Submerged inlet water-supply connections to water used for air washing, cooling, humidifying, and dehumidifying should not be allowed.

20. In buildings, water that flows in a pipe of considerable length under gravity, should never be used again in the domestic supply system. The chances of the pipe being used for a waste connection are too great.

21. Tests indicate that the vacuum causing flow of air through rim ports of closet bowls and urinals, or through or over other surfaces likely to have polluted liquid drops adhering to them, should not be over 1 inch of water in order to prevent the picking up of polluted liquid droplets and the carrying back of such pollution in the form of a spray into the water-supply pipes.

22. Most of the vacuums that occur in water pipes are caused by improper pipe sizing and by use of fittings and valves which introduce excessive friction loss. At least 90 percent of all vacuum formations could be prevented if water-piping systems were sized and installed correctly.

Following this research program, the directors of this association approved in November 1937 the establishment of a national plumbing inspection laboratory to be operated somewhat similarly to the National Board of Fire Underwriters' laboratory. It is believed that the establishment of such a laboratory will do much toward the standardization of plumbing fixtures from the public health viewpoint, and the elimination of poorly designed and insanitary fixtures from the market.

Since the adoption by the *Wisconsin State Board of Health* of a State plumbing code in 1914, the board of health has taken an active interest in plumbing and its relation to public health. Research work to determine the possibilities of contaminating a water supply through the medium of defective plumbing fixtures and installations was carried out at the University of Wisconsin under the direction of the State board of health. A result of this work was the publication of a bulletin on interconnections in plumbing and water-supply systems by that board in conjunction with the university officials. This bulletin gives a most complete picture of the hazards presented by defective plumbing fixtures and installations.

Besides these investigative interests, the State board of health has revised its plumbing code to provide for the elimination and prevention of these public health dangers. Surveys for the location of existing defective installations have been and are being made and corrective action is being taken. Educational programs for the instruction of plumbers and plumbing inspectors have been carried on from time to time.

The *National Bureau of Standards* has conducted, during the past year, a research into interconnections in the plumbing of buildings. A complete outline of the work done and the results obtained will be found in a recent publication (*191*) of that Bureau but an abstract of it is given herewith:

This paper deals principally with the technical aspects of the problem of preventing the backflow of water from plumbing fixtures into water-supply systems. It starts with a general review of the subject, including a brief history of previous work on the subject, a classification of cross-connections, and a brief discussion of vacua and siphon action. This is followed by a mathematical and experimental analysis of the conditions tending to produce backflow into a supply line. This analysis makes it possible to determine the worst conditions, as regards backflow, that can occur in any building supply system, and to determine minimum requirements for the positive prevention of backflow under these conditions. Specifically, the minimum pressure that can occur in any system, the maximum rate at which water can be removed from the supply risers under this minimum pressure, the smallest air gap between a faucet and plumbing fixture that can be safely allowed under the worst conditions, and the essential performance characteristics of a siphon breaker are determined. The effectiveness of various types of siphon breakers in preventing backflow is discussed, and the operation of one type of flush valve is explained in order to show the essentials of a stable flush valve, that is, one which will not open under any possible reduction in supply pressure. Finally, there is given a brief review of the entire subject of preventing backflow from plumbing fixtures, in which two distinct methods of attack are pointed out, and the merits of each are discussed. The conclusions relate only to technical aspects of the subject and do not take the form of proposed health or plumbing regulations.

In contrast to those organizations which have specialized in research work in the problem of back-siphonage and interconnections, others have devoted their efforts toward the location and determination of the prevalence of this type of health hazard. This work was carried out through surveys of plumbing and plumbing fixtures. In some cases, representative buildings of various types were studied; in others, particular types of buildings were thoroughly gone over; while in still others, a number of buildings of all types were covered.

A survey was made by the *St. Louis Health Department* of various hotels, swimming pools, pasteurization plants, and hospitals in Missouri for the purpose of ascertaining the extent of plumbing hazards to the public health. The scope and the plan of the survey were as follows:

The work was undertaken as an F. E. R. A. project with a group of engineers of varying experience. It was planned to survey several buildings used for the following purposes: swimming pools, hotels, milk plants, and hospitals, since these probably represented the greatest potential hazard to the public health. While the entire program was planned on the basis of an investigation or demonstration, as required by the F. E. R. A., nevertheless, it was deemed necessary to do the work in a systematic thorough manner, otherwise many typical defects in the types of buildings chosen might be missed and the purpose of the survey defeated. Consequently, no attempt was made to cover a large number of buildings, but rather to survey thoroughly a few places representative of each of the several classes of structures chosen. (*196*)

The following conclusions were drawn from the results of the work:

(1) Past, and particularly more recent investigations of the danger to health from faulty plumbing within buildings indicate beyond a question of a doubt the responsibility, as well as potentialities, of such defects for causing such filth-borne diseases as dysentery and typhoid fever.

(2) A survey of plumbing within representative types of buildings indicated that probably in all our cities many plumbing defects exist, which past experience indicates will, under not unlikely circumstances, cause the dangerous contamination of water and food with the resulting exposure of individuals to pathogenic organisms. Further, this survey was sufficiently extensive to conclude that the existence of such defects is prevalent in buildings used for numerous purposes and, undoubtedly, exists in buildings constructed for residential purposes, particularly the larger apartment houses.

(3) Irrespective of the past or future jurisdiction of plumbing ordinances, this condition constitutes such a distinct and dangerous hazard to the public health that its control necessarily becomes a subject of grave importance to health departments, as well as water departments, and a responsibility which they cannot escape or delegate. (*196*)

After the outbreak of amebic dysentery in Chicago in 1933, *the Baltimore Health Department* inaugurated an active interconnection prevention and elimination program which is still in effect. The program is here outlined in brief:

1. The Baltimore city health department is vested by ordinance, with the control and installation of all plumbing.

2. A reorganization of some of the department activities in 1932 made possible the development of the public health aspects of plumbing by establishing a division of plumbing in the bureau of environmental hygiene.

3. A training course in the fundamental principles of public health with particular emphasis placed on cross-connections in defective plumbing was given the plumbing inspector staff.

4. Attention of the plumbing trade was called to the regulations prohibiting potential cross-connections by circular letter informing them that the requirements would be rigidly enforced.

5. The installation of a small exhibit demonstrating the possibility of contaminating the water supply as a result of potential cross-connections in plumbing systems was set up in one of the department laboratories for educational purposes.

6. The inauguration of a program of reinspection of plumbing in all buildings where considerable number of persons congregate or are employed such as hotels, hospital buildings, office buildings and industrial establishments.

7. The inspection of and subsequent elimination of all cross-connections in swimming pools.

8. Since the regulations pertaining to cross-connections in plumbing systems are not retroactive, corrections have been accomplished largely by educational methods.

9. Careful review of all plans for plumbing by the chief inspector of plumbing in order to be assured that no cross-connections are included.

The following table is an indication of the progress made since attention has been focused on the public health aspects of plumbing. Cross-connections eliminated by the bureau of water supply of the department of public works are not included.

***Cross-connections prevented or eliminated in Baltimore***

| *Year:* | *Number* |
|---|---|
| 1933 | 195 |
| 1934 | 282 |
| 1935 | 436 |
| 1936 | 973 |
| 1937 | 1,669 |

In connection with the reinspection of plumbing in buildings a careful check of the piping system and all fixtures is made. The number of types of potential or actual cross-connections found are listed in order of relative importance and incorporated in a letter to the owner or manager of the building, explaining the situation and pointing out methods for correction. Follow-up visits are made for the purpose of pointing out and explaining the significance of the plumbing defects. This procedure has been found helpful in obtaining corrections.[9]

In 1933 the *San Francisco Water Department* inaugurated a cross-connection elimination program. This study was supplemented by an investigation into the prevalence of plumbing defects as is explained below:

While the survey was being made to locate secondary sources of water supply it was noted that the water and sewer pipes in a good many buildings and industrial plants were cross-connected. Therefore, it was decided, upon the completion of the survey of other sources of water supply to continue the survey, working toward the elimination of cross-connections between water and sewer pipes and other possible sources of contamination within the piping system. This work was not completed due to a curtailment of funds, but the work as far as it was carried indicated that about thirty percent of the buildings in downtown San Francisco had dangerous cross-connections between water and sewer pipes. In some cases sewage pumps, located in the basements of buildings, had a priming line connected to the pump in such a manner that it would be easily possible to pump sewage directly into the water piping of the building. Many buildings were connected with siphon ejectors in basement sumps to pump drainage water into the sewers and were so arranged that a vacuum in the water piping or a pressure in the sewage piping would force sewage into the water-piping system.

[9] Schulze, W. H. Personal communication.

Many buildings equipped with fire sprinkling systems are served with a large connection for fire-protection purposes. The automatic fire system in most cases was arranged to be tested through a bypass around the alarm system, discharging directly into the sewer pipe. It is understood that the San Francisco fire department requires that the ammonia piping installed in refrigeration plants be equipped with an outlet to the sewer for drawing off gas in case of breaks in ammonia piping. They also require that the ammonia piping be equipped with a water connection so that water may be sprayed into the ammonia piping dissolving the ammonia. In many cases these sewer, ammonia, water piping connections are close together, thus providing a direct connection between water and sewer lines. Should ammonia be present in the water pipes its high solubility could readily draw sewage into the water system. It is likely that at times of breaks, both water and sewer outlets would be open into the ammonia piping. Such times might readily be accompanied by a fire. This is an interesting case of conflict between the policies of the fire and water departments. Many buildings equipped with filters or water softeners were arranged in such a manner that the backwash line from the filter or softener discharged directly into the sewer pipe. A great number of plumbing fixtures were also found that had the water inlet pipes below the overflow level of the fixture. A number of pieces of hydraulicking equipment were found, arranged to utilize water pressure for washing or for a suction to remove wastes. All of these types of plumbing installations created a potential hazard to the purity of the potable water supply (*65*).

## *Connecticut State Department of Health.*

In order to eliminate the chance of an outbreak of water-borne diseases similar to the amebic dysentery outbreak in Chicago in 1933, the Connecticut State Department of Health has begun an inspection program with the cooperation of local health departments. In cities where this program is carried out, it is expected that all buildings over three stories in height, all stores above one story, and all factories, hospitals, theatres, and hotels will be inspected. This group of buildings includes the most dangerous possibilities of building water-supply pollution, although theoretically it would be desirable to inspect every building.

The survey in a city is suggested by the State department of health, and with the cooperation of the local health officer, an inspection form is arranged to assist the local inspector in carrying out the proposed program. A sanitary engineer of the State department of health accompanies the local inspector for two or more days at first to point out some of the undesirable conditions to look for. This is desirable in order to make certain the inspector understands the objective of the survey and is familiar with the more common systems to be encountered. Any unusual condition may be reinspected with the engineer of the State department of health.

The local inspector carries out this work along with his regular duties. Additional local inspection personnel is not usually available for this work with the consequence that a number of months may be required to complete each local survey. However, results are gradually being obtained.

While proper protection of drinking-water storage or cooling tanks is the primary objective, leading questions are asked on the inspection forms used regarding other tanks, air conditioning, refrigeration, and other mechanical equipment in order to bring about the elimination of any cross-connections which may endanger the public water supply. These items are specifically covered by section (a) of the recently adopted regulation 127 of the State sanitary code

218645—40——3

entitled, "Minimum Requirements for Drainage and Toilet Systems" which follows:

> "Plumbing and drainage systems shall be so constructed as to avoid contamination of safe drinking-water supplies in houses or buildings. There shall be no cross-connections between such safe water supplies and unsafe water supplies, nor shall such safe supplies be piped to refrigeration, air conditioning or other mechanical equipment provided with direct connections to drains or constructed in such a manner as to permit contaminated water to be siphoned or drawn into the water-supply pipes.
>
> "Storage of drinking water in buildings shall be only in covered tanks so constructed as to avoid any possible contamination of the water in the tanks. Sewer or waste lines located above storage tanks and direct overflows and drains to sewer systems are expressly prohibited."

Surveys are now under way in Hartford, New Haven, Bridgeport, New Britain, and Waterbury. These cities include all Connecticut cities with populations of more than 50,000 as indicated by the census of 1930. It is expected later to extend the survey to include towns and smaller cities.

The first local survey was started in Hartford in March 1937 and no other survey was attempted until the procedure followed in Hartford proved satisfactory. New Haven next undertook this work to be followed more recently by Bridgeport, Waterbury, and New Britain.

From March through December 1937, the Hartford board of health inspected 96 buildings. Of this number, 23 were found to have drinking-water tanks. At 10 locations, about 10 percent of the places inspected, these tanks were not adequately safeguarded against possible contamination. The buildings thus far inspected include most of the larger ones and therefore those most likely to have tanks.

In the course of the Hartford survey, two drinking-water cooling tanks were found which were not covered and were located directly beneath sanitary sewer pipes. Fortunately, these pipes were tight, but any leakage would have polluted the drinking water. Both of these conditions have been eliminated; one by the removal of the sewer line and provision of tight covers, and the other by the abandonment of the old cooling system and the installation of individual electric fountain coolers. The discovery of even one such condition would seem to warrant the time expended in these surveys.

Thirty-three of the 96 places mentioned were found to have tanks storing water for purposes other than drinking. Some of these tanks had submerged inlets, or inlets that might be submerged, thus permitting the suction of water from the tank into the water-supply piping should a vacuum occur in the latter. Vacuums sometimes are formed by excessive draft or a water-main break. Several direct connections to sewers from water lines through refrigeration and air-conditioning equipment have been found in the Hartford survey.

In all cases building owners or managers have been willing and even anxious to make any desired improvements after the hazards have been explained. Not all of the necessary reinspections have been made in Hartford as yet, but the improvements already obtained are very gratifying.

It is possible that conditions in other cities will be found similar to those in Hartford, and that improvements will as readily be obtained. When all of these surveys are completed, many dangerous possibilities of water-supply pollution will be eliminated. The surveys indicate the need not only of delivering safe water to buildings, but also of keeping the water safe after it enters buildings. (*266*)

Besides research and survey work, many agencies have attacked the problem of back-siphonage by drawing up new plumbing codes or by making changes in existing codes, prohibiting the installation of disapproved plumbing fixtures and interconnections. Some of these codes are negative in character and prohibit any connection through which contamination of the water supply may occur. Other codes are more constructive in nature and require that certain definite stated precautions be observed in the installation of plumbing fixtures. These precautions have been developed as a result of research work in this field. In the majority of cases, the plumbing codes or revisions as adopted by the various states or municipalities are not retroactive and no provision is made to cover defective installations and fixtures already in place.

The *State Board of Health of New Hampshire* (*190*) adopted as of March 9, 1938, several rules and regulations regarding plumbing. These rules are most explanatory in regard to public health aspects of plumbing fixtures and installations. Very clear and concise definitions of cross-connections and interconnections are given. A minimum allowable air gap between the highest possible water level in the fixture and an inlet is prescribed.

Not only are inter- and cross-connections prohibited in future work, but all existing installations in hospitals, laundries, places where processing water and chemicals or either are used, schools, educational buildings, and all other buildings of four stories and over are required to meet the specifications of these rules and regulations.

*New Bedford* (*Mass.*) *Water Department.*—Having found by inspections made in answer to complaints of poor water pressure, a growing tendency for the consumer to install fixtures which might prove hazardous to the quality of the water supply and the public health, the water department of New Bedford, Mass., adopted a set of rules and regulations, effective June 1, 1935, governing the installation of house piping. The following are some of the principal requirements:

Plans of proposed new installations or alterations of existing systems must be submitted to and approved by the water department before starting work.

All inside piping must be installed under the supervision of a master plumber except in plants where competent pipers are regularly employed and except that connections to hot-water heaters and similar equipment may be made by persons regularly engaged in installing such equipment; all subject to inspection and approval by the water board.

All installations are tested under city pressure in the presence of our inspector before acceptance.

It is required that the service be carried full size to the point where the last branch is taken off. Accessible separate shut-offs are required in the basement for each tenement and for each hot-water tank.

Concealed piping, tanks, etc., must be properly protected against freezing and must be tested before being concealed. The bottom of flush tanks for water closets or urinals must be above the overflow level of the fixture when the drain is obstructed.

All flushometer valves must be equipped with a vacuum breaker of approved type.

When the water is delivered to any receptacle below the overflow line of the receptacle when the drain is plugged, it is required that provision be made to prevent back-flow from the receptacle, by siphon breaker, check valve, or other approved method (*276*).

*Maine State Department of Health and Welfare.*—The bureau of health on June 1, 1926, adopted a plumbing code, setting forth minimum requirements for plumbing installations in the State of Maine and, at that time, provided for protection against contamination of water supplies through faulty plumbing. These regulations were revised on June 23, 1931, and on September 26, 1934. The final revision prohibits the installation of any connection by which the water supply may become contaminated. Section 82 of the revised code reads as follows:

Water supply pipe connections to swimming pools, hospital sterilizers, bedpan sterilizers, toilets, urinals or to any other plumbing fixture shall be made in a manner so as to make impossible the return of any of the water, liquid or waste from the swimming pool, sterilizer, toilet, urinal or other plumbing fixture to the water-supply distributing system either by gravity or syphonage.

In addition to the above, the State laws require the submission of plans for all new school buildings or repair work in such buildings, and for the last 2 years before such plans were approved it has been required that all water closets equipped with flush valves shall be provided with approved vacuum breakers.[10]

*Kahler Corporation, Rochester, Minn.*—The following corrective and preventive measures are applied to all of the establishments owned and operated by the Kahler Corporation. This corporation owns and operates several hospitals, cafeterias, laundries, dormitories, and hotels.

Lavatory faucets should be provided with a gap of ¾ inch between the lip of the faucet and the rim of the lavatory.

Bathtubs should be provided with the same gap between the faucet and the rim of the tub.

Closets should be of the tank type and the filling tube should be above the water line in the tank; that is, above the overflow point.

Steam tables should be fed with water by means of an over-the-rim faucet. The drain for these should empty into an open pot trap.

Sinks should be provided with over-the-rim feed.

Dishwashers should be supplied with water by means of a faucet that is higher than the overflow point—about ¾ inch.

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[10] Campbell, E. W. Personal communication.

There should be a distinct break in the water line before supplying potato peelers.

Water fed to condensers should, upon leaving the condenser, be emptied into an open pot trap.

A sitz bath should be fed, preferably, from a faucet over-the-rim of the tub above the overflow point of the bath. (If this is not possible a device may be arranged whereby the water empties into a standpipe a foot or so above the bath.) This standpipe feeds the sitz bath below the rim and this same standpipe, being open at the top, provides a vent to eliminate all possibility of back-siphonage.

Continuous flow baths should be handled the same as sitz baths.

Bidets should be fed from an open hopper. This hopper should be of a height to provide the proper water pressure. The break in the continuity in this case would be between the water line and the hopper.

Instrument and utensil sterilizers should be supplied with water by means of a swinging over-the-rim faucet. In this case, the faucet must be swung out of place before the cover of the sterilizer can be lowered. The waste line from the sterilizers should empty into an open pot trap.

It is satisfactory to supply a water sterilizer direct but when the water leaves the sterilizer, it must be provided with a break in the continuity. The waste line should empty into an open pot trap before reaching the sewer.

All water suction devices or aspirators are a hazard and all new installations should provide suction by means of a vacuum pump. A vacuum pump and receiving tank should be located some place in the building and each room piped to this vacuum tank. When the suction is used, a receiver is installed in the room which collects any foreign matter in order to keep the suction system clean.[11]

The *American Water Works Association* through its committee No. 8 on cross-connections has made an extensive study of this subject. The committee presented to the association at Memphis, Tenn., on May 2, 1932, an exhaustive report. This was approved in 1933 by the committee on water works practice and published in the American Water Works Association Journal of March 1933.

The committee then presented to the association an additional report which was published in the journal of December 1936. It included a brief description of the types of cross connections which were involved in the outbreak of amebic dystenery in Chicago in 1933, a short résumé of new regulations enacted, enforcement activities and experiences for the 2 years preceding the presentation of the report, and conclusions based on these incidents.

On June 7, 1934, the following motions were adopted by the association:

(1) That the recommendation of the committee on waterworks practice be adopted that the hotel where an American Water Works Association annual convention is to be held be required to submit a certified plan of their water supply and drain piping and a certificate from the State board of health in which the city is located that there are no dangerous insanitary conditions existing.

(2) That the secretary, on behalf of the convention committee, be instructed to make a written report to the board on the sanitary conditions of the conven-

[11] Myrick, G. H. Personal communication.

tion hotel to be presented at the time of the recommendation of the convention committee on choice of city and hotel.

As a result of the adoption of these two motions, a committee on hotel sanitation was appointed, whose report was submitted to the association and approved by the board of directors, January 16, 1936. This report was published in the journal of the association in February 1936, and defined more fully the requirements for certification of a hotel for use of the association in holding its annual meeting. (*61*)

*Detroit (Mich.) Department of Buildings and Safety Engineering.*—During the course of the past year (1937) the department of buildings and safety engineering of Detroit has installed a plumbing laboratory which includes a permanent demonstration installation, by means of which back-siphonage hazards may be shown, as well as having the facilities for testing fixtures, vacuum breakers, and other plumbing equipment for their efficiency of operation.

This laboratory became available in November 1937. Since that time public health classes, senior architectural students from the University of Michigan, committees of plumbers, engineers, real-estate management representatives, sanitary engineers, public health nurses, builders, and industrial representatives have seen the hazards that may be found in the present plumbing installations.

Last April, as a result of certain preliminary studies that were secured from other municipalities and from our Detroit board of health, a bulletin was issued demanding that all water supplies be brought in above the rim of the fixture, the heights of the openings being dependent upon the size of the fixture supply. If the operation of the fixture was dependent upon a submerged supply and it was not feasible to bring the supply above the rim of the fixture, it was requested that all such devices be equipped with vacuum breakers. This included ball cocks for tank-supplied water closets, lawn sprinkler systems, soda fountains and bar equipment, shampoo hoses, and other submerged connections as well as the flushometer-operated water closets.

The effective date of this bulletin has been set forward at various intervals because the industry, in general, has no satisfactory vacuum breakers for some of the equipment. It finally became effective January 1, 1938.

As rapidly as inventors found that facilities for testing such equipment were available they began bringing their ideas to be tested. As a result several ball cocks, equipped with vacuum breakers that are satisfactory have been found. The design of vacuum breakers for small supplies has been aided by this means.

A combination vacuum breaker and valve has very recently been accepted for installation in the city of Detroit, that protects against the possibility of back siphonage through lawn-sprinkling systems.

At the present time work is being conducted on several types of vacuum breakers for flushometer supplied closets. A combination closet bowl and tank, invented by a local man, introducing a revolutionary principle for its flushing operation, has been tested in our laboratory and found satisfactory. It may appear on the market in the near future.

An investigation is being conducted, at the present time, on dishwashing machines and the new type of automatic washing machines which are connected to the water and waste systems.

A tentative study of a type of installation found in connection with air-conditioning systems is being made and so far only general recommendations, with reference to cross-connections have been made.[12]

[12] Shields, L. G. Personal communication.

The *Copper and Brass Research Association* has contributed towards the education of health groups, plumbers' associations, and various other related organizations to the dangers of defective plumbing installations. A motion picture illustrating the phenomenon of back-siphonage and the resultant contamination of the water supply has been made available by this association for educational purposes.

The *Massachusetts Department of Public Health* in 1937 conducted a survey of several State institutions for the purpose of determining the prevalence of plumbing fixtures and installations which were capable of becoming a hazard to the public health and to the quality of the water supply. The results of this work showed that 1,066 fixtures out of a total of 3,525 inspected in 5 State institutions contained either cross-connections or submerged inlets and were capable of allowing back-siphonage to occur under certain conditions.

As a result of this study, the committee making it recommended the following:

The State examiners of plumbers be authorized to establish rules and regulations relative to the construction, alteration, repair, and inspection of all plumbing work within the Commonwealth as provided in appendix XXIII of House Document No. 1200 of 1937 and that authority be extended to include all public buildings and public institutions except Federal buildings and Federal institutions (*211*).

The *Joint Committee on Plumbing of the American Public Health Association and the Conference of State Sanitary Engineers* presented a progress report at a session of the public health engineering section on October 28, 1930. This report stressed the necessity for a further investigation into the relation between plumbing and public health and for a better control of the plumbing system by health and waterworks officials. It also included a final report on Essential Features in the Design of Sanitary Drinking Fountains which have already been discussed.

Further progress reports of this joint committee presented in 1935 and 1937 briefly summarized the work accomplished by various agencies in plumbing survey and research fields, together with the new developments in the plumbing industry, up to the time of presentation of the respective reports.

The following is a resolution adopted by the *Twentieth Annual Texas Water Works and Sewerage Short School at College Station, Tex.*, February 17, 1938:

Whereas, the public health of the State of Texas has been and is being jeopardized by the installation of improperly designed plumbing fixtures and appliances, and

Whereas, such fixtures and appliances are continuing to be marketed and installed throughout the State, and

Whereas, no central or common agency exists for the impartial and competent study, testing and approving of plumbing fixtures and appliances which would result in standardization and consequent savings to manufacturers and consumers alike, and

Whereas, the A. & M. College and the State University are equipped or can successully and economically be equipped for the impartial and competent study, testing, and approving of plumbing fixtures and appliances and do further research work concerning the application of properly designed plumbing fixtures and appliances to the public health and formulate codes and standards for control and regulation of the design, manufacture, and installation of such fixtures and appliances: Now therefore be it

*Resolved* by the Twentieth Annual Texas Water Works and Sewerage Short School that the State department of health give diligent thought and careful consideration to a plan or procedure of cooperation with either the A. & M. College, the University of Texas, or other State agencies in the establishment of a laboratory and sufficient competent personnel for the study, testing, and approval of plumbing fixtures and appliances and the formulation of codes and regulations for their design, manufacture and installation.

## *Louisiana State Department of Health.*

In this department, for some time, particular attention was paid to the matter of cross-connections in the work on inspection of water supplies and sewerage systems. This activity is being extended to include inspections of piping arrangements at industrial plants. A number of inspections have been made, and a number of various types of cross-connections and arrangements which would permit back-siphonage have been found. To facilitate correspondence diagrams have been prepared showing representative defects and acceptable methods of correction.

Lack of personnel prevents doing systematic work on plumbing inspection. Activity by local agencies is being promoted. Special attention is given to this problem by the plumbing division of the sewerage and water board of New Orleans, and all new work is required to be in order. It has not been possible yet to secure much change in old work except in public buildings and hotels.

The Delgado Trades School, New Orleans, has cooperated by installing in the plumbing department of the school equipment for demonstrating the dangers of back-siphonage and for testing protective devices, such as vacuum breakers. The Baton Rouge water company at Baton Rouge has also installed a demonstration set-up.[13]

## *Minnesota State Department of Health.*

The Minnesota State Legislature, in 1933, passed a law which relates to the licensing of plumbers, the supervision and inspection of plumbing and the adoption and enforcement of minimum standards of the State board of health. Under the provisions of this act, all plumbers in municipalities with a population of 5,000 people or more are required to obtain a license issued by the State board of health. Examinations are usually held twice a year for applicants who are seeking either the master or journeyman's license.

The department of health drew up a plumbing code as authorized under the provisions of the 1933 law, and has since been recommending its adoption to municipalities throughout the State. In the original law, the code was set up as a mandatory document; in the amended law, passed in 1937, the board

[13] O'Neill, J. H. Personal communication.

is given authority to make mandatory regulations on plumbing, but the board made a few minor changes in the code and adopted it again as an advisory code and is continuing to recommend its adoption through local ordinances. A good many municipalities have adopted the code in this manner, and many others have it under consideration. Although the code may not be adopted by all municipalities, however, State departments, the Works Progress Administration and the Public Works Administration have agreed to require adherence to the code for all new plumbing installations under their control or subject to the approval of such governmental agencies. Plans and specifications for such projects are submitted to the Minnesota Department of Health for examination before installations are made. One or more field inspections are made before the fixtures are installed, and then a final inspection is made after the installation of the fixtures and other equipment has been completed.

Investigations have been made of plumbing in many buildings for the purpose of determining to what extent cross-connections exist, and to study the causes of pressure variations under normal operation in the water-supply system. The public health engineers in the large cities and those in the rural health unit districts of the State are at present making surveys of cross-connections in certain buildings in their respective cities and districts.

The department of health, in cooperation with the hydraulics department of the University of Minnesota, has been doing research work on plumbing fixtures and devices with the view of obtaining data which can be used as a basis for setting up minimum standards for their design and installation, the application of which should eliminate the possibility of contamination getting into the water-supply system. The equipment in the hydraulics laboratory has been arranged so that demonstrations can be given, and has been set up with plumbing fixtures and appurtenances commonly found in buildings and homes throughout the State. Such demonstrations have been given to many people who are interested in this phase of public-health work.

For the purpose of conveying some of its findings and data obtained by research to those who are interested in this work but who are unable to visit the laboratory, the Minnesota Department of Health has developed some motion pictures and lantern slides of typical cross-connections, and these are being used extensively throughout the State as a means of educating people to the hazards of faulty plumbing design and installations.

A bulletin has been prepared in which a number of sanitary plumbing fixtures are being shown. Other data including that obtained from field investigations and research work, are also presented.[14]

### *El Paso, Tex.*

A modern plumbing ordinance was passed by the city of El Paso, Tex., which prohibits the installation of devices which may endanger the safety of the city water supply and embodies other regulations which are intended for improving sanitary conditions from a standpoint of plumbing.

This ordinance is now being placed in operation and many improvements in plumbing are being experienced. From time to time defective and inadequate plumbing which is a probable source of contamination is found and caused to be removed.[15]

### *Houston, Tex.*

It has been found in surveying the several hospitals located in Houston, Tex., that very few of the instrument, water, and bedpan sterilizers were properly

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[14] Whittaker, H. A. Personal communication.
[15] Carr, J. M. Personal communication.

equipped to prevent back-siphonage into the drinking-water lines in the buildings. In one hospital a toilet bowl was found which was so equipped that bedpans were washed by a submerged outlet in the toilet bowl which at all times constituted a cross-connection between both the hot and cold water lines within the building.

The water department has worked closely with the plumbing inspection department in securing the installation of vacuum breakers on flushometer valves. The water and plumbing departments have an agreement with the Master Plumbers Association of the city to include the installation of approved vacuum breakers on all repair work done by them. Of course, all new flushometer valves installed as new have approved vacuum breakers built into the valve fixture. The exact number of vacuum breakers on new and old plumbing is not immediately ascertainable, but it is estimated that more than 3,000 have been installed within the last 3 years.

Incidentally, the plumbing inspection department has constructed a display to demonstrate the occurrence of back-siphonage in all types of defective plumbing equipment which cost in excess of $3,000 and is located in the city hall. This piece of construction has proven most helpful in demonstrating to building managers and owners the desirability of eliminating defective plumbing where possible.[16]

In addition to the organizations already mentioned, there have been a number of individual investigators in this field. These have covered several phases of the problem and have contributed much work of value. One investigation [17] worthy of note undertook to determine the prevalence of disapproved lavatories and bathtubs as exemplified by their having below-the-rim inlets, or standing or secret wastes. The results of this investigation, given in table III, were obtained from a study of the catalogues of the various manufacturers of plumbing equipment and from actual inspections of the fixtures on sale in various salesrooms.

**Table III.**—*Percent of fixtures surveyed and found unsatisfactory in regard to water inlet and drainage outlet*

| Firms | Bathtubs | | | Lavatories | | |
|---|---|---|---|---|---|---|
| | Number surveyed | Percent unsatisfactory | | Number surveyed | Percent unsatisfactory | |
| | | Water inlets | Drainage outlets | | Water inlets | Drainage outlets |
| A | 103 | 78 | 73 | | | |
| B | 16 | 69 | 62 | | | |
| C | 50 | 16 | 10 | 54 | 61 | 0 |
| D | 163 | 54 | 45 | 29 | 78 | 0 |
| E | 34 | 53 | 65 | 88 | 69 | 0 |
| F | 10 | 40 | 60 | 19 | 63 | 32 |
| G | 16 | 50 | 25 | 32 | 69 | 6 |
| H | 4 | 0 | 0 | | | |
| J | 26 | 73 | 62 | 27 | 55 | 7 |
| K | 21 | 100 | 57 | 64 | 59 | 0 |
| L | | | | 28 | 72 | 0 |
| M | | | | 4 | 0 | 0 |
| P | | | | 23 | 17 | 0 |
| R | | | | 28 | 32 | 0 |
| Total 14 | 443 | | | 396 | | |
| Averages | | 58 | 50 | | 60 | 3 |

[16] Harvill, C. R. Personal communication.

[17] Collins, Willis E., Thesis, Harvard Graduate School of Engineering, 1937 (unpublished material).

# CHAPTER III

## SURVEY OF PLUMBING IN FEDERAL BUILDINGS IN NEW YORK AND DETROIT

Joint resolution No. 254 was passed by the seventy-fourth Congress, first session, requiring the Public Health Service to make a survey of plumbing in all Federal buildings in the United States for the purpose of determining whether there existed any hazards to public health similar to those which were the cause of the amebic dysentery epidemic in Chicago in 1933. As no appropriation was provided to carry on the survey, this resolution was vetoed by the President.

The Public Health Service was then asked to propose a project to the Works Progress Administration providing for a survey of plumbing in Federal buildings in the United States. At a conference to determine the extent of such a proposed survey, it was decided to set up a limited project to include only the Federal buildings in New York, N. Y., and Detroit, Mich.

The number of supervisory personnel required for such an experimental project would be small and it would be practicable to give the special training required for technical employees before beginning the work. Methods of approach to and means of accomplishment of such a study, both unknown at the outset of the work, could be determined more readily on a small project than on one encompassing the entire country. An opportunity would be presented to observe the suitability of Works Progress Administration beneficiaries for work of this character. It was believed, also, that the findings of a survey in two sample cities would be fairly representative of conditions existing in all Federal buildings and, to a certain extent, in all public and quasi-public buildings. The two major cities chosen were selected because it was believed that they presented the most likely opportunity for obtaining Works Progress Administration beneficiaries suitably qualified to carry out the work.

Accordingly, the Works Progress Administration, with the Public Health Service acting as cosponsor, initiated a project covering these two cities. Work was begun in May 1936 and continued until June 1937.

*Organization of staff.*—The working force was separated into three main divisions: (1) field inspections, (2) laboratory, and (3) administrative and drafting.

The field inspection group was the nucleus about which the entire survey organization was constructed. Field parties performed the actual inspections, prepared the preliminary reports, and made the decisions as to whether or not plumbing fixtures and installations fell in the category of potential health hazards. The Works Progress Administration roll of relief recipients was lacking in personnel qualified to serve as field inspectors and it was necessary to select these men from nonrelief sources. The men chosen were, for the most part, recent graduates in sanitary or allied engineering courses. They were given 4 weeks' training at New York University on the technique of plumbing inspection, together with lectures on public-health hazards, cross-connections, back-siphonage, and water-borne diseases.

Upon the completion of the training course the engineers were divided into six field parties each consisting of a chief of party, one or more engineers, from one to four plumbers, and from one to three handymen obtained from the work-relief roll. The six chiefs of party were selected from among the engineers completing the training course. Each supervised the operations of his field group, maintained the necessary link between the field and office forces and supervised and assisted in the writing of the preliminary field reports. The engineers, with the aid of the chiefs of party, inspected the plumbing and fixtures, prepared the field sketches and composed the field reports. The plumbers, handymen, and laborers furnished such assistance as was required.

The laboratory personnel included a chief, several assistant bacteriologists, and a number of attendants trained in the technique of proper water sample collection. This division cooperated with the field force in the collection and bacteriological examination of water samples taken from supplies in the various buildings inspected, and wherever the condition of the plumbing in a building warranted it, exhaustive tests were run. Limitations imposed on the work of the laboratory by the occupancy of the buildings and the necessity for continuous use of water restricted the laboratory's usefulness to the project.

The administrative and drafting division had in its drafting section a supervising draftsman and a number of draftsmen selected from the relief roll of the Works Progress Administration. These men, under close supervision and with the assistance of the chiefs of party, prepared the finished drawings from the field sketches. The force of stenographic and clerical workers in the administrative section of the division under the guidance of the office engineer transposed the field notes into the final reports. These data, with

the finished drawings and sketches, tabulations and photographs, comprised the finished reports for each Federal department which, after careful checking by the supervising engineer in charge of the project, were forwarded to the Public Health Service for transmittal to the respective department secretaries.

The manner in which the staff was coordinated is shown in figure 7.

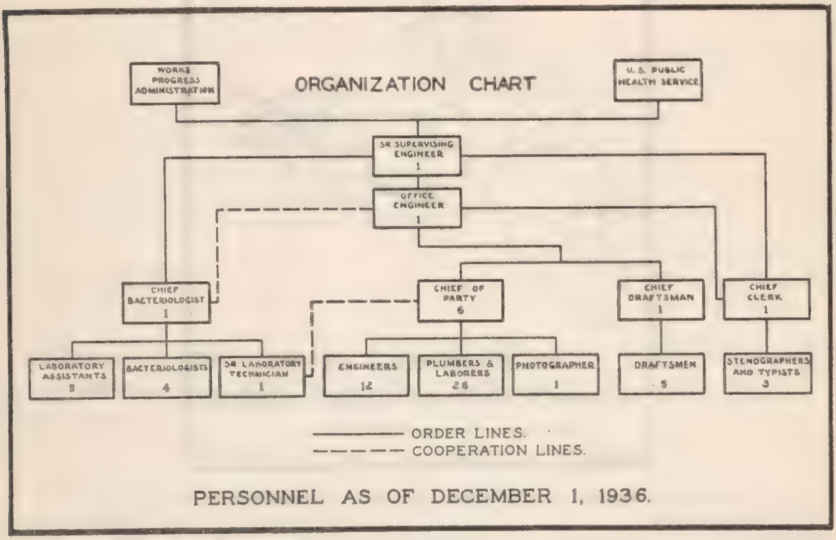


FIGURE 7.—Organization chart.

*Scope of work.*—While the scope of this project was limited to the Federal buildings in two cities, the large number of structures to be inspected necessitated the development of a simplified system of identification. This was accomplished by means of a group and unit scheme. Each separate group of structures in each of the two cities was given a group number. (For locations of the various groups, see figs. 8 and 9.) Each group was then subdivided by giving each structure in it a unit number. Plot plans of groups having more than one or two units were included in the reports to indicate the locations of the respective units. Throughout all of the work and in the final reports reference was made to buildings only by their group and unit assignment. In cases where more than one Government department controlled buildings in the same group, a subdivision of the group was made; as, for instance, group 2 and 2A. These subdivisions were in turn divided into units to correspond with the other groups. Table IV gives, by departments in each of the two cities, the number of groups and units and the floor area of the structures in each department.


FIGURE 8.—Location of groups of buildings inspected in New York.

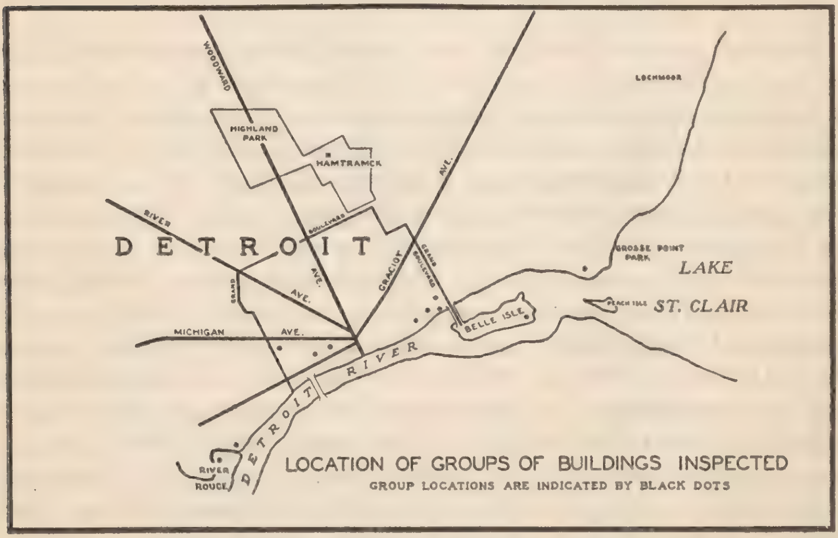


FIGURE 9.—Location of groups of buildings inspected in Detroit.

**Table IV.—*Number of structures and floor area***

NEW YORK, N. Y.

| Department | Number of— Groups | Number of— Units | Floor area in square feet |
|---|---|---|---|
| A | 1 | 35 | 645,375 |
| B | 25 | 25 | 5,028,094 |
| C | 8 | 62 | 2,046,271 |
| D | 4 | 5 | 849,147 |
| E | 7 | 34 | 156,111 |
| F | 1 | 11 | 460,000 |
| G | 10 | 638 | 8,762,990 |
| | 56 | 810 | 17,947,988 |
| DETROIT, MICH. | | | |
| A | 3 | 15 | 45,185 |
| B | 3 | 3 | 356,682 |
| C | 3 | 58 | 427,786 |
| D | 1 | 8 | 55,550 |
| E | 2 | 12 | 185,155 |
| | 12 | 96 | 1,070,358 |
| Total (both cities) | 68 | 906 | 19,018,346 |

Table V classifies the buildings or structures (each being a unit irrespective of size, use, or shape) in accordance with their height and floor area.

**Table V.—*Structures classified by height*** [1]

NEW YORK, N. Y.

| Number of stories | Number of structures | Percent of total number of structures | Floor area in square feet | Percent of total floor area |
|---|---|---|---|---|
| 1 | 376 | 46.4 | 1,035,738 | 5.8 |
| 2 | 104 | 12.9 | 1,755,308 | 9.8 |
| 3 | 193 | 23.8 | 1,959,178 | 10.9 |
| 4 | 43 | 5.3 | 1,772,820 | 9.9 |
| 5 | 9 | 1.1 | 388,558 | 2.2 |
| Over 5 | 17 | 2.1 | 10,615,399 | 59.1 |
| Unclassified | 68 | 8.4 | 420,987 | 2.3 |
| DETROIT, MICH. | | | | |
| 1 | 39 | 40.7 | 87,681 | 8.2 |
| 2 | 7 | 7.3 | 47,176 | 4.4 |
| 3 | 31 | 32.3 | 483,393 | 45.1 |
| 4 | 15 | 15.6 | 250,010 | 23.4 |
| 5 | 3 | 3.1 | 132,438 | 12.4 |
| Over 5 | 1 | 1.0 | 69,600 | 6.5 |
| Unclassified | 0 | 0.0 | 0 | 0.0 |

[1] Basements and subbasements are counted as stories.

Another differentiation of the structures has been made in table VI. Here they are shown in accordance with their use. While most of them are readily classified, a number, especially in New York, failed to fit under any general heading and have been listed as unclassified.

**Table VI.—*Classification of structures by use***

NEW YORK, N. Y

| Type of structure | Number of units | Percent of total number of units |
|---|---|---|
| Residences | 261 | 32.2 |
| Dormitories, multiple apartments, and barracks | 59 | 7.3 |
| Office buildings | 32 | 3.9 |
| Hospitals | 28 | 3.5 |
| Unclassified | 430 | 53.1 |

DETROIT, MICH.

| Type of structure | Number of units | Percent of total number of units |
|---|---|---|
| Residences | 32 | 33.3 |
| Dormitories, multiple apartments, and barracks | 6 | 6.3 |
| Office buildings | 12 | 12.5 |
| Hospitals | 2 | 2.1 |
| Unclassified | 44 | 45.8 |

*Report preparation.*—To prevent the final inspection reports from becoming too large and thus being lessened in value, a simplified method of presenting the results of the work to each department was devised. This comprised:

1. A general department report, presenting (*a*) a history of the project, (*b*) the problem involved, (*c*) an outline of the inspection organization, (*d*) a short summary describing the order and method of presentation of the material collected, and (*e*) a general discussion of plumbing defects or deficiencies and health hazards with detailed explanations and illustrations of the more common defects.

2. A list of groups of buildings under the jurisdiction of the department with an accompanying map showing the location of each group in the city.

3. A brief group report, preceding the detailed unit reports of that group, containing information pertaining to the group as a whole.

4. For all groups having more than one or two units, a list showing (*a*) the unit number used for the purpose of the survey, (*b*) the number assigned to the unit by those in charge of its maintenance, (*c*) the name of the unit, (*d*) its height, and (*e*) its approximate floor area.

5. A map showing the location of each unit in the group with the identifying unit numbers. Such a map was not prepared for a group consisting of only one or two units.

6. The unit reports in numerical order. For larger units a complete description of the water and sewerage systems was given for a full understanding of the remainder of the report and following that, a summary of all plumbing defects separated into six general classifications. In small units it was possible to include all of the information on one sheet.

In the larger units, defective fixtures were tabulated so as to show their location and with reference symbols to indicate the riser connection in the basement or pipe gallery feeding them. In the last column of the tabulation was given the type of defect or a reference to a detail drawing or photograph which, supplemented with explanatory remarks, further clarified the report. The commoner defects, repeated in many buildings, were explained in the general discussion of plumbing defects and mentioned only by name in the tabulation.

When it was desirable to show complete piping lay-outs, isometric sketches giving all essential details and the reference symbols heretofore mentioned were inserted at the end of the unit report.

*Summary of results.*—In order to present the results of the survey in a simple yet complete form, two tabulations of the findings in each of the two cities were made. Table VII gives the number of fixtures inspected and table VIII the number disapproved for each type of building. (The term "disapproved" is used here to denote those fixtures which fall in the category of plumbing installations which, under certain conditions, may present a hazard to the public health.) It is impossible in this tabulation of results to qualify in any way the potential degree of danger attached to any of the fixtures.

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**Table VII.—*Number of fixtures inspected***

NEW YORK

| Fixture | Type of building | | | | | |
|---|---|---|---|---|---|---|
| | Residences | Dormitories, multiple apartments, and barracks | Office buildings | Hospitals | Unclassified | Totals |
| Lavatories | 700 | 1, 220 | 3, 062 | 769 | 928 | 6, 679 |
| Flushometer closets | 306 | 662 | 2, 483 | 345 | 906 | 4, 702 |
| Low-tank closets | 317 | 77 | 24 | 47 | 236 | 701 |
| High-tank closets | 81 | 44 | 195 | 148 | 123 | 591 |
| Other type closets | 1 | 16 | 1 | 13 | 17 | 48 |
| Bath tubs | 596 | 270 | 5 | 159 | 49 | 1, 079 |
| Laundry trays | 396 | 231 | 4 | 20 | 39 | 690 |
| Sinks | 420 | 261 | 154 | 249 | 374 | 1, 458 |
| Showers | 136 | 394 | 190 | 191 | 311 | 1, 222 |
| Urinals | 8 | 208 | 1, 102 | 115 | 404 | 1, 837 |
| Slop sinks | 7 | 82 | 424 | 180 | 79 | 772 |
| Drinking fountains | | 93 | 424 | 85 | 89 | 691 |
| Pumps | 3 | 1 | 49 | 5 | 4 | 62 |
| Hot water storage tanks | 111 | 38 | 28 | 8 | 42 | 227 |
| Tanks (miscellaneous) | | 1 | 44 | 11 | 17 | 73 |
| Laundry washers | | | 1 | | 28 | 29 |
| Miscellaneous submerged inlets | | | 5 | | 1 | 6 |
| Miscellaneous sinks | | | 3 | 9 | 2 | 14 |
| Miscellaneous sterilizers | | 3 | | 11 | 1 | 15 |
| Miscellaneous utensil washers | | | | 5 | 5 | 10 |
| Miscellaneous machines | | | | 9 | 7 | 16 |
| Water-sewer connections | | | | 1 | | 1 |
| Cross-connections | | | 2 | | 1 | 3 |
| Pump priming lines | | | 1 | | 1 | 2 |
| Refrigerating machines | 2 | 3 | 2 | 4 | 5 | 16 |
| Dishwashers | | 5 | | 27 | 8 | 40 |
| Soup kettles | | 3 | | 14 | 8 | 25 |
| Steam tables | | 3 | 1 | 14 | 11 | 29 |
| Water filters | | | 5 | | 1 | 6 |
| Vegetable cookers | | | | 3 | 8 | 11 |
| Bedpan washers | | | | 20 | | 20 |
| Treatment baths | | | | 17 | | 17 |
| Water stills | 2 | | 2 | 4 | 3 | 11 |
| Bar sinks | | | | | 2 | 2 |
| Boilers | 167 | 34 | 20 | 4 | 59 | 284 |
| Pressure ejectors | | | 5 | | | 5 |
| Suction ejectors | 19 | 7 | 8 | 3 | 5 | 42 |
| Developing tanks | 1 | | 14 | 15 | 8 | 38 |
| Dental cuspidors | | | 3 | 31 | 2 | 36 |
| Bedpan sterilizers | | 1 | | 44 | | 45 |
| Water sterilizers | | | | 17 | 1 | 18 |
| Instrument sterilizers | | | 2 | 17 | 1 | 20 |
| Utensil sterilizers | | | | 36 | | 36 |
| Autoclaves | 1 | 1 | 3 | 16 | 3 | 24 |
| Cooling jackets | | | 11 | 5 | 14 | 30 |
| Air conditioners | | | 21 | 22 | 2 | 45 |
| Sitz baths | | | | 6 | | 6 |
| Potato peelers | | 5 | | 14 | 4 | 23 |
| Coffee urns | | 11 | | 13 | 18 | 42 |
| Autopsy tables | | | | 3 | | 3 |
| Floor drains | | | | 1 | 25 | 26 |
| Watering troughs | 1 | | | | 8 | 9 |
| Print washers | 1 | | 2 | | 2 | 5 |
| Soap melting pots | | 2 | | | 4 | 6 |
| Grease removing tanks | | | | | 1 | 1 |
| Lye vats | | | | | 1 | 1 |
| Starch mixers | | | | | 2 | 2 |
| Lime boxes | | | | | 1 | 1 |
| Water softeners | | | | | 1 | 1 |
| Paint stripping vats | | | | | 1 | 1 |
| Grease traps | | | | 1 | | 1 |
| Swimming pools | | | | | 1 | 1 |
| Material washers | | | 4 | | | 4 |
| Straddle stands | | | | 7 | | 7 |
| Cooling towers | | | | 1 | | 1 |
| Coffee roasters | | | | | 3 | 3 |
| Printing machines | | | 3 | | 2 | 5 |
| Miscellaneous | | | 5 | | 46 | 51 |
| Total | 3, 276 | 3, 676 | 8, 312 | 2, 739 | 3, 925 | 21, 928 |

**Table VII.—*Number of fixtures inspected*—Continued**

DETROIT

| Fixture | Type of building | | | | | |
|---|---|---|---|---|---|---|
| | Residences | Dormitories, multiple apartments, and barracks | Office buildings | Hospitals | Unclassified | Totals |
| Lavatories | 116 | 177 | 567 | 130 | 11 | 1,001 |
| Flushometer closets | 33 | 94 | 263 | 60 | 4 | 454 |
| Low-tank closets | 92 | | 46 | 6 | 8 | 152 |
| High-tank closets | 11 | | 8 | | 1 | 20 |
| Other type closets | | | | 8 | 2 | 10 |
| Bathtubs | 106 | 14 | | 30 | | 150 |
| Laundry trays | 81 | 19 | 1 | | | 101 |
| Sinks | 67 | 17 | 14 | 28 | 8 | 134 |
| Showers | 11 | 38 | 20 | 18 | 3 | 90 |
| Urinals | 5 | 41 | 132 | 12 | 1 | 191 |
| Slop sinks | 1 | 10 | 44 | 15 | | 70 |
| Drinking fountains | 5 | 13 | 77 | 10 | 4 | 109 |
| Pumps | | | 10 | | 1 | 11 |
| Hot water storage tanks | 54 | 10 | 11 | | 4 | 79 |
| Tanks (miscellaneous) | | | 11 | 1 | | 12 |
| Laundry washers | | 3 | | | | 3 |
| Miscellaneous submerged inlets | | | | | 1 | 1 |
| Miscellaneous sinks | | | 5 | | | 5 |
| Miscellaneous sterilizers | | | | | | |
| Miscellaneous utensil washers | | | | | | |
| Miscellaneous machines | | | | | | |
| Water-sewer connections | | | | | | |
| Cross-connections | | | | | | |
| Pump priming lines | | | | | | |
| Refrigerating machines | | | 3 | | | 3 |
| Dishwashers | 1 | 1 | 1 | 9 | | 12 |
| Soup kettles | | | | | | |
| Steam tables | 1 | 1 | 1 | | | 3 |
| Water filters | | | | | | |
| Vegetable cookers | | | | | | |
| Bedpan washers | | | | | | |
| Treatment baths | | | | 2 | | 2 |
| Water stills | | | | | | |
| Bar sinks | | | | | | |
| Boilers | 34 | 8 | 8 | 1 | 3 | 54 |
| Pressure ejectors | | | | | | |
| Suction ejectors | | | 4 | | | 4 |
| Developing tanks | | | 8 | | | 8 |
| Dental cuspidors | | | 1 | 3 | | 4 |
| Bedpan sterilizers | | | | 8 | | 8 |
| Water sterilizers | | | | 3 | | 3 |
| Instrument sterilizers | | | | 2 | | 2 |
| Utensil sterilizers | | | | 9 | | 9 |
| Autoclaves | | | | 4 | | 4 |
| Cooling jackets | 1 | | | 2 | 1 | 4 |
| Air conditioners | | | | | | |
| Sitz baths | | | | 6 | | 6 |
| Potato peelers | | 5 | 1 | 1 | | 7 |
| Coffee urns | | | 1 | | | 1 |
| Autopsy tables | | 1 | | | | 1 |
| Floor drains | | | | 1 | | 1 |
| Watering troughs | | | | | | |
| Print washers | | | 1 | | | 1 |
| Soap melting pots | | | | | | |
| Grease-removing tanks | | | | | | |
| Lye vats | | | | | | |
| Starch mixers | | 1 | | | | |
| Lime boxes | | | | | | |
| Water softeners | | | | | | |
| Paint stripping vats | | | | | | |
| Grease traps | 3 | | | | | 3 |
| Swimming pools | | | | | | |
| Material washers | | | | | | |
| Straddle stands | | | | | | |
| Cooling towers | | | | | | |
| Coffee roasters | | | | | | |
| Printing machines | | | | | | |
| Miscellaneous | 1 | | | 1 | | 2 |
| Total | 623 | 453 | 1,238 | 370 | 52 | 2,736 |

## Table VIII.—*Number of disapproved fixtures*

NEW YORK

| Fixture | Type of building | | | | | |
|---|---|---|---|---|---|---|
| | Residences | Dormitories, multiple apartments, and barracks | Office buildings | Hospitals | Unclassified | Totals |
| Lavatories | 614 | 1,040 | 2,664 | 506 | 741 | 5,565 |
| Flushometer closets | 306 | 662 | 2,483 | 345 | 906 | 4,702 |
| Low-tank closets | 317 | 77 | 24 | 47 | 235 | 700 |
| High-tank closets | 81 | 44 | 195 | 148 | 123 | 591 |
| Other type closets | 1 | 16 | 1 | 12 | 17 | 47 |
| Bathtubs | 468 | 126 | 5 | 92 | 35 | 726 |
| Laundry trays | 248 | 127 | 4 | 15 | 19 | 413 |
| Sinks | 11 | 6 | 7 | 8 | 25 | 57 |
| Showers | | | | | | |
| Urinals | 2 | 4 | 245 | 36 | 15 | 302 |
| Slop sinks | 1 | | 102 | 32 | 13 | 148 |
| Drinking fountains | | 85 | 364 | 82 | 82 | 613 |
| Pumps | 1 | 1 | 16 | | 1 | 19 |
| Hot-water storage tanks | 8 | 2 | | 8 | 10 | 28 |
| Tanks (miscellaneous) | | 1 | 26 | 9 | 11 | 47 |
| Laundry washers | | | 1 | | 28 | 29 |
| Miscellaneous submerged inlets | | | 5 | | 1 | 6 |
| Miscellaneous sinks | | | 2 | | 1 | 3 |
| Miscellaneous sterilizers | | 3 | | 11 | | 14 |
| Miscellaneous utensil washers | | | | 2 | 5 | 7 |
| Miscellaneous machines | | | | 2 | | 2 |
| Water-sewer connections | | | | 1 | | 1 |
| Cross-connections | | | 2 | | 1 | 3 |
| Pump-priming lines | | | 1 | | 1 | 2 |
| Refrigerating machines | 2 | 3 | 2 | 4 | 3 | 14 |
| Dishwashers | | 5 | | 27 | 8 | 40 |
| Soup kettles | | 3 | | 6 | 8 | 17 |
| Steam tables | | 3 | | 11 | 6 | 20 |
| Water filters | | | 5 | | 1 | 6 |
| Vegetable cookers | | | | | | |
| Bedpan washers | | | | 20 | | 20 |
| Treatment baths | | | | 17 | | 17 |
| Water stills | | | 2 | 2 | | 4 |
| Bar sinks | | | | | 1 | 1 |
| Boilers | 166 | 34 | 19 | 4 | 58 | 281 |
| Pressure ejectors | | | 3 | | | 3 |
| Suction ejectors | 19 | 7 | 8 | 3 | 5 | 42 |
| Developing tanks | | | 11 | 14 | 8 | 33 |
| Dental cuspidors | | | 3 | 31 | 2 | 36 |
| Bedpan sterilizers | | 1 | | 44 | | 45 |
| Water sterilizers | | | | 16 | | 16 |
| Instrument sterilizers | | | 2 | 16 | | 18 |
| Utensil sterilizers | | | | 35 | | 35 |
| Autoclaves | 1 | | 3 | 12 | 2 | 18 |
| Cooling jackets | | | 11 | 5 | 9 | 25 |
| Air conditioners | | | 21 | 22 | 2 | 45 |
| Sitz baths | | | | 6 | | 6 |
| Potato peelers | | 3 | | 4 | 1 | 8 |
| Coffee urns | | 4 | | | | 4 |
| Autopsy tables | | | | 3 | | 3 |
| Floor drains | | | | 1 | 25 | 26 |
| Watering troughs | | | | | 1 | 1 |
| Print washers | 1 | | 2 | | 2 | 5 |
| Soap melting pots | | | | | 4 | 4 |
| Grease removing tanks | | | | | 1 | 1 |
| Lye vats | | | | | 1 | 1 |
| Starch mixers | | | | | 2 | 2 |
| Lime boxes | | | | | | |
| Water softeners | | | | | | |
| Paint-stripping vats | | | | | 1 | 1 |
| Grease traps | | | | | | |
| Swimming pools | | | | | 1 | 1 |
| Material washers | | | 4 | | | 4 |
| Straddle stands | | | | | | |
| Cooling towers | | | | 1 | | 1 |
| Coffee roasters | | | | | | |
| Printing machines | | | 2 | | 2 | 4 |
| Miscellaneous | | | 5 | | 6 | 11 |
| Total | 2,247 | 2,257 | 6,250 | 1,660 | 2,430 | 14,844 |

## Table VIII.—*Number of disapproved fixtures*—Continued

DETROIT

| Fixture | Type of building | | | | | |
|---|---|---|---|---|---|---|
| | Residences | Dormitories, multiple apartments, and barracks | Office buildings | Hospitals | Unclassified | Totals |
| Lavatories | 113 | 177 | 553 | 129 | 10 | 982 |
| Flushometer closets | 33 | 94 | 263 | 60 | 4 | 454 |
| Low-tank closets | 91 | | 46 | 6 | 8 | 151 |
| High-tank closets | 11 | | 8 | | 1 | 20 |
| Other type closets | | | | 8 | 2 | 10 |
| Bathtubs | 99 | 2 | | 15 | | 116 |
| Laundry trays | 67 | | | | | 67 |
| Sinks | 1 | | | 3 | 1 | 5 |
| Showers | | | | | | |
| Urinals | | | 6 | | 1 | 7 |
| Slop sinks | | 1 | | | | 1 |
| Drinking fountains | 5 | 7 | 77 | 10 | 4 | 103 |
| Pumps | | | 2 | | | 2 |
| Hot water storage tanks | | | 2 | | | 2 |
| Tanks (miscellaneous) | | | 6 | 1 | | 7 |
| Laundry washers | | 3 | | | | 3 |
| Miscellaneous submerged inlets | | | | | 1 | 1 |
| Miscellaneous sinks | | | | | | |
| Miscellaneous sterilizers | | | | | | |
| Miscellaneous utensil washers | | | | | | |
| Miscellaneous machines | | | | | | |
| Water-sewer connections | | | | | | |
| Cross-connections | | | | | | |
| Pump-priming lines | | | | | | |
| Refrigerating machines | | | 3 | | | 3 |
| Dishwashers | 1 | 1 | 1 | 9 | | 12 |
| Soup kettles | | | | | | |
| Steam tables | 1 | 1 | 1 | | | 3 |
| Water filters | | | | | | |
| Vegetable cookers | | | | | | |
| Bedpan washers | | | | | | |
| Treatment baths | | | | 2 | | 2 |
| Water stills | | | | | | |
| Bar sinks | | | | | | |
| Boilers | 34 | 8 | 4 | 1 | 3 | 50 |
| Pressure ejectors | | | | | | |
| Suction ejectors | | | | | | |
| Developing tanks | | | | | | |
| Dental cuspidors | | | 1 | 3 | | 4 |
| Bedpan sterilizers | | | | 8 | | 8 |
| Water sterilizers | | | | 3 | | 3 |
| Instrument sterilizers | | | | 2 | | 2 |
| Utensil sterilizers | | | | 9 | | 9 |
| Autoclaves | | | | 4 | | 4 |
| Cooling jackets | 1 | | | 2 | 1 | 4 |
| Air conditioners | | | | | | |
| Sitz baths | | | | 6 | | 6 |
| Potato peelers | | 4 | | 1 | | 5 |
| Coffee urns | | | | | | |
| Autopsy tables | | | | | | |
| Floor drains | | | | 1 | | 1 |
| Watering troughs | | | | | | |
| Print washers | | | | | | |
| Soap-melting pots | | | | | | |
| Grease-removing tanks | | | | | | |
| Lye vats | | | | | | |
| Starch mixers | | | | | | |
| Lime boxes | | | | | | |
| Water softeners | | | | | | |
| Paint stripping vats | | | | | | |
| Grease traps | 3 | | | | | 3 |
| Swimming pools | | | | | | |
| Material washers | | | | | | |
| Straddle stands | | | | | | |
| Cooling towers | | | | | | |
| Coffee roasters | | | | | | |
| Printing machines | | | | | | |
| Miscellaneous | 1 | | | 1 | | 2 |
| Total | 461 | 298 | 973 | 284 | 36 | 2,052 |

From tables VII and VIII it can be noted that the number of fixtures inspected in Federal buildings in New York and Detroit were 21,928 and 2,736 respectively or a total of 24,664. The number of fixtures listed as disapproved in New York was 14,844 and in Detroit 2,052, being respectively 67.7 percent and 75.0 percent of the plumbing installations inspected in the two cities.

## DISCUSSION OF CERTAIN PHASES OF SURVEYS

In addition to the statistical results embodied in the preceding section, there are several conclusions that may be drawn relative to the carrying out of the survey itself. The extensiveness and completeness of that survey permit comment on:

(1) The suitability of Works Progress Administration beneficiaries for work of this nature, (2) the proper method of attack to be used in making a plumbing inspection survey, (3) the efficiency of the inspection organization, (4) the desirability of recording results in the manner used in this survey, and (5) the value of the recorded results as an indication of the necessity for a closer control of plumbing in various buildings.

The *Works Progress Administration* was designed primarily to furnish gainful and creative employment for persons on relief. As such, it is essential for sound economy and effectiveness that the various projects undertaken furnish a maximum opportunity for the use of work-relief labor. The amount of work furnished by a survey of this nature is limited and the work is of such a character that it requires the employment of a number of specially trained men for its successful completion. These men must be able to understand and visualize the various factors influencing the conversion of a plumbing fixture into a health hazard. Men of the caliber necessary to satisfactorily conduct and carry out a plumbing inspection survey are not to be found, except in rare instances, on relief rolls. It is evident, therefore, that either the quality and accuracy of the survey results are reduced by the use of men from relief rolls regardless of their qualifications for the task, or else the essential purpose of work-relief projects is destroyed through the employment of nonrelief personnel to carry out the work. Since both of these alternatives are undesirable, it is evident that a plumbing inspection survey of this nature is unsuitable for a work-relief project.

*Development of procedure.*—It was necessary at the start of the survey to develop a tentative procedure to be followed in making the inspections. This tentative procedure was in the form of a questionnaire (see Appendix A), the answers of which were to be the results of the inspection. Upon application of this method of re-


218645—40 (Face p. 46)

FIGURE 10.—ISOMETRIC VIEW OF SUB-BASEMENT PLUMBING.

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porting results it immediately became apparent that it was not comprehensive enough in some cases and in others too cumbersome. As a result, the questionnaire was not used as intended but rather as a guide for the inspectors to follow. In this way, it proved to be quite useful and of instructional value. A procedure more applicable to the variable conditions encountered was consequently developed. This was outlined in a series of instructions issued to the engineers in the field (see appendix B) and it allowed considerable leeway to the various field parties in preparing their reports.

The instruction sheet as issued provided for a most comprehensive report on the plumbing of all the buildings inspected. It was soon found, however, that the results obtained were not commensurate with the time and labor spent in following these instructions. Therefore, the procedure to be followed was again simplified by permitting exceptions to that part of the instructions requiring complete drawings of all the plumbing systems, the exceptions to be made on the judgment of the chief of each party with the concurrence of the office engineer. This action speeded up the progress of the field parties to a measurable degree. As a further means of lessening the time necessary for making an inspection and recording the results, a photographer was made available to the field parties to photograph special equipment thereby eliminating the need for a number of complicated and involved sketches.

*Drawings, sketches and photographs.*—In the larger buildings, a complete drawing of the water-distribution system in the basement or pipe gallery was required. This was considered essential to a complete understanding of the system and as a check on the progress and extent of the inspection work. The hazard presented by the improper installation of several fixtures is not always fully realized when only a visual inspection, fixture by fixture, is made. In several cases, a critical examination of the drawings of the water distribution and sewerage systems in a building indicated the existence of a more dangerous situation than was revealed by the visual inspection. For example, in one of the buildings in New York, the connection of a water line to a waste pipe through the cooling jacket of an ammonia condenser was observed. The hazard in this connection was based on the facts that a vacuum on the water line supplying the cooling jacket might cause contamination to be drawn from the waste pipe through the condenser and into the water supply or that a surcharging of the waste line might cause contamination to be forced rather than drawn back into the water-supply line. It was not realized, however, until after the water and sewer piping had been sketched just how much danger was presented by the last possibility. A critical study of the drawings showed that the waste pipe into which the cooling water of the ammonia condenser discharged was,

in reality, the discharge line from a centrifugal pump used to force waste water into a sewer at a higher level. Further, this discharge line was under a continuous positive pressure.

Another illustration of the value of the drawings of a distribution system as an aid in comprehending what is happening to the water supply of a building can be explained by reference to figure 10. On this drawing, in about the center of the north side of the building, there can be seen two sewage ejectors and to the right and directly above them the two air compressors that supply the air to the ejectors. These two air compressors are equipped with cooling jackets supplied by a 1-inch branch from the water distribution system. The water, after passing through the cooling jackets, wastes into the discharge line of one of the sewage ejectors. The rated discharge pressure of the sewage ejector is 40 pounds per square inch whereas the water pressure at the meter is 45 pounds per square inch.

On figure 10, the 1-inch water line can be traced back to its connection with the main distribution pipe. Starting at the connection with the cooling jackets of the air compressors and tracing the line in the other direction the following branches from the 1-inch pipe are noted:

1. C–46.
2. C–43.
3. C–44.
4. Vacuum cleaner system.
5. Line to cool bearing of fan.
6. Line to water jacket.
7. Connection to main distribution system.

An examination of the report of the inspection party on this building showed that the following fixtures were located on the branches listed above:

1. C–46—3 lavatories, 1 shower.
2. C–43—1 lavatory, 1 shower.
3. C–44—2 flush tanks, 6 urinals, 4 lavatories.
4. Dust and wash tanks of vacuum cleaner system.
5. Water-cooled bearings on fan.
6. Water jacket on pump.

In other words the 1-inch branch from the main distribution system in the basement serves 21 other fixtures besides the cooling jackets of the air compressors. With this many fixtures on this 1-inch line, the possibility of the water pressure in this line at the cooling jackets becoming less than 40 pounds per square inch, the rated discharge pressure of the sewage ejector, is imminent.

Figure 11 is a photograph of the plumbing hazard just explained. On it the small line marked with an arrow is the 1-inch water line. It divides and goes to the cooling jackets of the 2 air compressors (covered line). Upon leaving the cooling jackets the 2 lines are

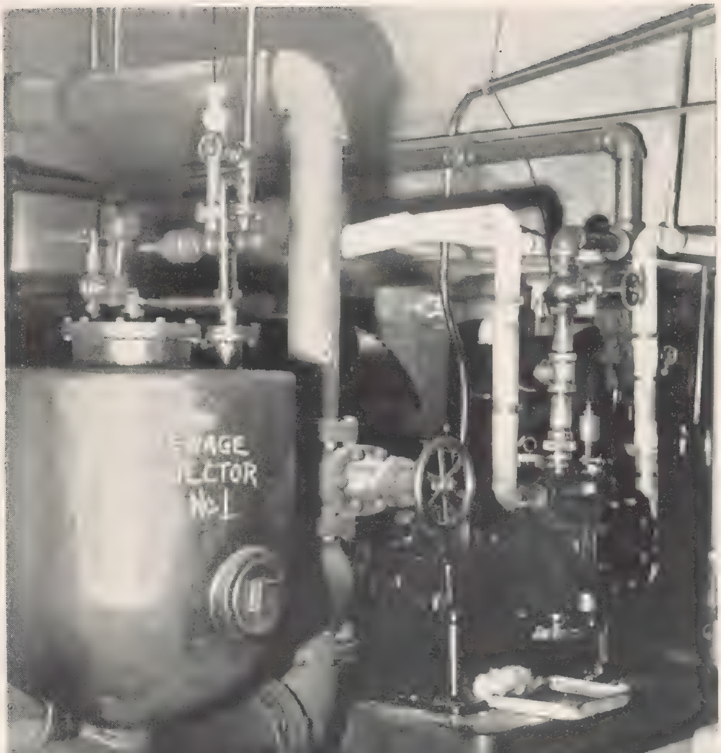


FIGURE 11.—SEWAGE EJECTOR INTERCONNECTION.

again combined and are connected into the discharge line of sewage ejector No. 1 (line marked "S"). This photograph, while showing the actual hazardous connection, in no way indicates the presence of the 21 other fixtures connected to the 1-inch water line between this point and its connection with the main distribution system. This explanation shows that while photographs may serve to reduce sketching, it is important that they be used judiciously and not be permitted to take the place of drawings where the latter are obviously needed.

Besides a complete drawing of the distribution and collection systems of the larger buildings, it is often advantageous to prepare detailed sketches of special defects. These drawings may be simple line drawings on a large scale or they may be complete drawings of the machine or installation. The number and completeness of such drawings will depend upon the magnitude of the survey. Finished and accurate drawings of pumps, sewage ejectors, and other pieces of equipment and machinery, if found in a number of buildings, may be desirable for repetitive use.

Figure 12 illustrates a sewage pump installation common to several buildings inspected in New York. The peculiar nature of this particular pump installation necessitated its illustration. The supply line to these pumps is open at all times so that the pump is primed continuously. As can be seen in the supplementary sketch on figure 12, if a vacuum were to occur on the supply line, the water in the rotor chamber would be drawn back and a suction would be created in the pump chamber. As the level of the sewage rises in the chamber the float would rise opening the air break. If the float should stick or the air break be insufficient in size the sewage could be drawn into the rotor chamber and from there into the cold water line of the building. There is also the possibility of contamination being drawn back from the pump pit through the ½-inch discharge line from the rotor chamber.

*Detailed descriptions.*—In addition to drawings, detailed sketches, and photographs, it is essential that a written description of the cold, hot, and drinking water distribution, the fire and sewerage systems be included in reports. These will assist materially in a better understanding of the reports and of the many factors that may exert an influence upon the fixtures and installations in use in the buildings covered.

The usefulness of such descriptions may be illustrated by an example taken from a report on one of the buildings inspected in New York. This building has several drainage sumps in the subbasement for collecting seepage water and one (a foundation well) is emptied

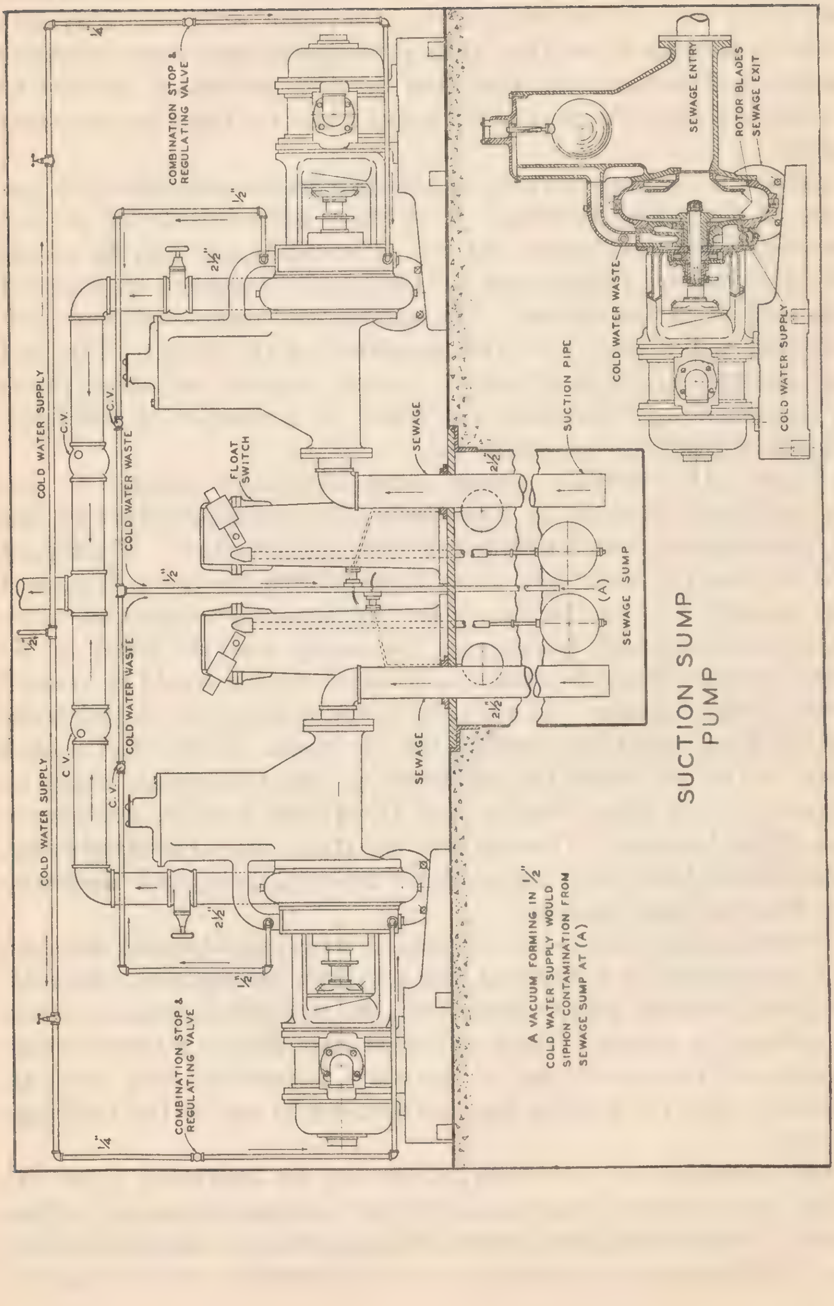


FIGURE 12. — Suction sump pump.

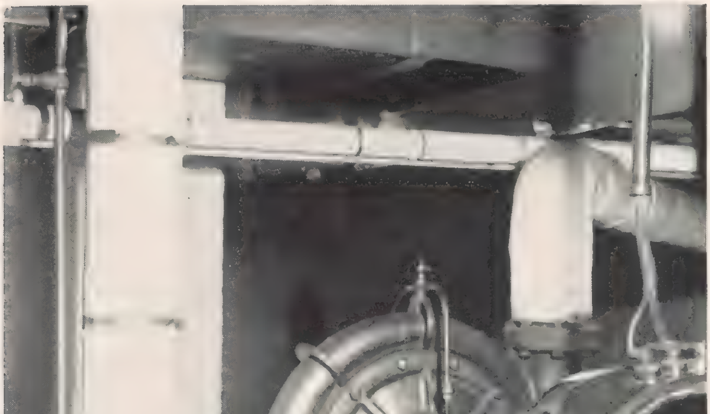

FIGURE 13.—PRIMING LINE FOR CENTRIFUGAL PUMP.

by the centrifugal pump shown in figure 13 forcing the seepage 13 feet into the house drain at a point near the house trap.

A branch from the main supply line taken off near the suction end of the house pumps is used to fill the suction leg of the centrifugal pump after repacking. With a vacuum on the water line and an open or leaky control valve, contamination may be drawn from the foundation well into the water supply of the building. Even with no pressure in the water line, the pump side of the supply valve may be subject to a head of 13 feet or more should the sewer back up through the centrifugal pump. That such a condition occurs is shown by an excerpt from the description of the sewerage system in that same report:

> It was learned that at times of high tide and with a northwest wind considerable backing up of the sewers is noted. Under such conditions neither the sewage ejectors nor the centrifugal pump (see fig. 13) can force the sewage or drainage water into the house sewer. Valves on the sewer outlets are closed and the sewage from the building is allowed to back up in the drains until the condition is relieved.

As noted before, the methods employed by the field parties both in their inspections and in preparing their reports were such as to enable the office engineer to detect plumbing defects overlooked in the field upon a critical examination of the sketches, drawings, and descriptions handed in by a party chief. This valuable checking scheme proved its worth in several instances and, as a secondary result, brought about a clearer understanding of plumbing plans in the minds of those engaged in field work.

The listing of the various defective fixtures found in a building by riser number, floor and room number, type of fixture, or installation of specific deficiency was intended to facilitate location of the various defects for purposes of checking or correction. This method of defining the location of fixtures, especially when drawings of the distribution system are included, is simple, requires little space, yet affords an accuracy almost as great as if the location of each fixture had been individually described. Modifications of this method may be made to fit any variable conditions encountered. For example, for buildings where room numbers are not available, the location of the fixtures on the various floors may be made by sections; the list of the defective fixtures to include a reference symbol indicating the location of the fixture on the particular floor as shown on a key plan of the building or on the drawing of the distribution system.

*Procedure for small buildings.*—The foregoing discussion has pertained principally to the inspection of large buildings, little mention being made of the procedure followed in small structures such as residences, small offices, storehouses, and shops. In these smaller structures, the piping systems are simple, the fixtures few in number

and their location an easy matter. As a result, the inspection of these buildings may be accomplished in a short time. No drawings are necessary in most instances and photographs are not required except in special cases.

*Record of fixtures.*—As an adjunct to the regular inspection report, a file card for each building was kept giving the total number of fixtures of each type that were approved and disapproved and the total

GROUP NO.____ NAME OF BUILDING UNIT NO.____

ADDRESS

TOTAL NO. OF FIXTURES____ TOTAL NO. OF DEFICIENCIES____

TYPES OF FIXTURES

| NAME OF FIXTURE | NO. APPR. | NO. DISAPPR. | TOTAL | NAME OF FIXTURE | NO. APPR. | NO. DISAPPR. | TOTAL |
|---|---|---|---|---|---|---|---|
| LAVATORIES | | | | BOILERS | | | |
| FLUSHOMETER CLOSET | | | | PRESSURE EJECTORS | | | |
| LOW TANK CLOSET | | | | SUCTION EJECTORS | | | |
| HIGH TANK CLOSET | | | | DEVELOPING TANKS | | | |
| OTHER TYPE CLOSET | | | | DENTAL CUSPIDORS | | | |
| BATH TUBS | | | | BED PAN STERIL. | | | |
| LAUNDRY TRAYS | | | | WATER STERIL. | | | |
| SINKS | | | | INSTRUMENT STERIL. | | | |
| SHOWERS | | | | UTENSIL STERIL. | | | |
| URINALS | | | | AUTOCLAVE | | | |
| SLOP SINKS | | | | COOLING JACKETS | | | |
| DRINKING FNTNS. | | | | AIR CONDITIONERS | | | |
| PUMPS | | | | SITZ BATH | | | |
| H.W.STOR.TANK | | | | POTATO PEELERS | | | |
| TANKS (MISC.) | | | | COFFEE URNS | | | |

FIGURE 14.—Plumbing survey file card.

number of fixtures inspected. This card, illustrated in figure 14, is no more than a numerical summary of the results of the inspection. It has proven extremely helpful for many purposes and should be made a part of the inspection report procedure. Fixtures and installations not appearing on the face of the card may be listed on the back.

*Recording progress of survey.*—The progress made by the field parties was estimated by the square feet of floor area covered. Figure 15 is a sample progress chart on which the total floor space for each department, estimated carefully at the start of the project, is shown under the heading of "total." The progress of the field and the office work is figured on that basis and is listed under those headings. This method of recording progress was not entirely satisfactory, but no better substitute could be found for it due to the lack of information on the procedures to be followed in making a survey of this nature and of basic data such as are given in tables IX and X. It was thought early in the survey that the size of the building would bear a certain relationship to the amount of plumbing to be inspected but this was soon found to be incorrect. A warehouse containing

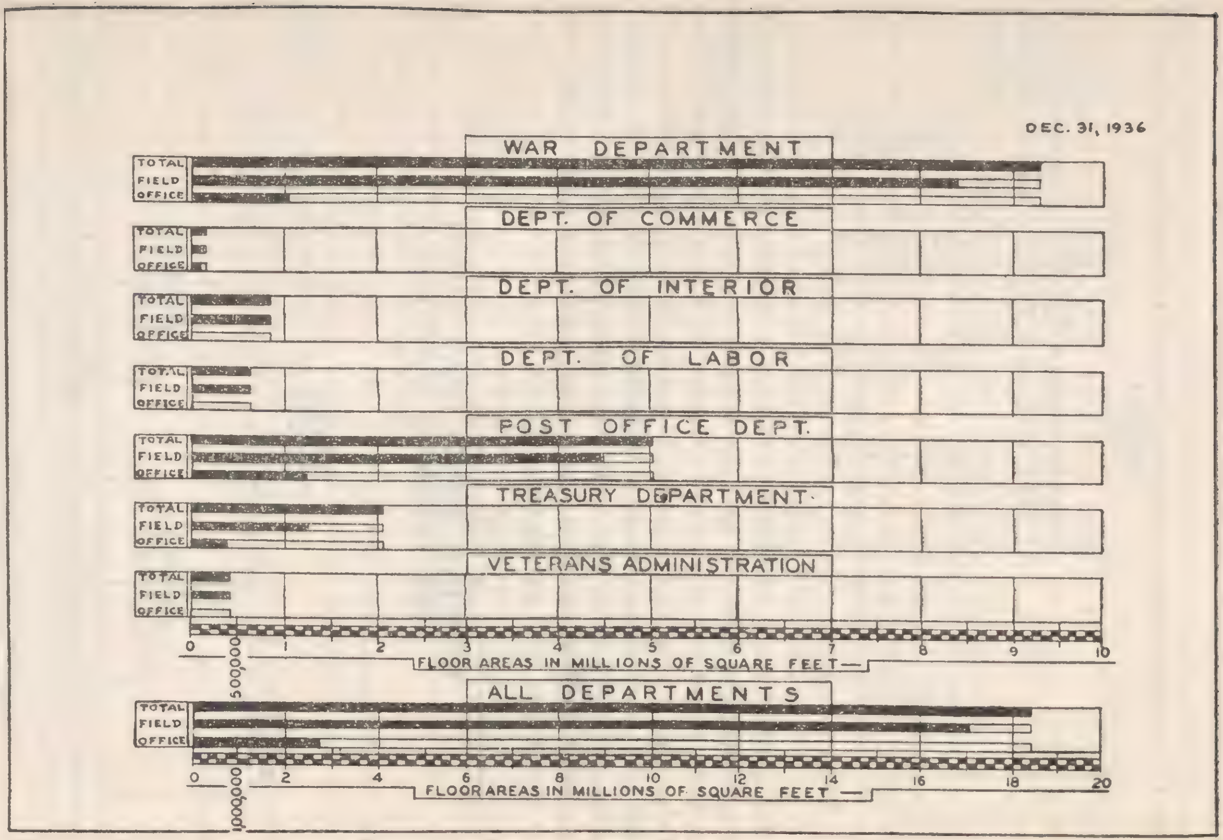


FIGURE 15.—Progress chart by Federal departments.

little or no plumbing would have many times the floor area of a small office building and complicated and involved piping systems in power plants with a small floor area often necessitated a very intensive study of the different systems in order to complete the inspection.

**Table IX.**—*Average number of fixtures inspected per working-party-month in New York*

| Working-party number | Number of months employd | Number of buildings inspected | Floor area of buildings inspected in square feet | Number of fixtures inspected | Average number of fixtures inspected per month of employment |
|---|---|---|---|---|---|
| 1 | 13 | 330 | 2, 791, 353 | 6, 179 | 475 |
| 2 | 7 | 45 | 1, 360, 782 | 2, 448 | 350 |
| 3 | 7 | 155 | 6, 415, 017 | 3, 220 | 460 |
| 4 | 7 | 244 | 2, 017, 939 | 4, 501 | 643 |
| 5 | 7 | 16 | 3, 305, 029 | 2, 977 | 425 |
| 6 | 7 | 20 | 2, 057, 868 | 2, 603 | 372 |
| Total | 48 | 810 | 17, 947, 988 | 21, 928 | 457 |

For future work of this description, a more accurate means of determining the efficiency and progress of a number of field parties would be to use as a measure the number of fixtures inspected. Data of this kind for each of the six field parties in New York are given in table IX. As the parties spent varying periods of time in the field, the number of months each party was employed is given. From the number of months employed, the average number of fixtures inspected per month has been calculated.

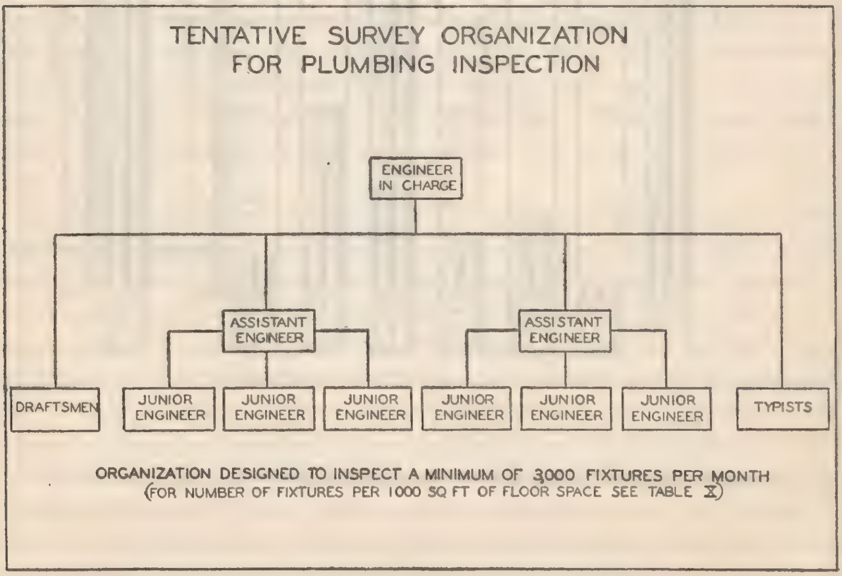


FIGURE 16.—Survey organization for plumbing inspection.

The average number of fixtures inspected per month per field party is fairly consistent although the number appears lower than might be expected. This latter condition is due to the completeness with which the survey was carried out. In surveys of a similar nature it may be possible to increase the number of fixtures inspected per month by not requiring so much detail.

*Suggested organization for future surveys.*—The organization as established for this plumbing inspection project was necessarily cumbersome and less efficient than would be the case for a permanent organization. Figure 16 illustrates a tentative survey organization the composition of which has been based upon observations as to the value, ability, and function of the various individuals on the surveys in New York and Detroit and on the assumption that it would be a permanent organization. This group has been designed to inspect and report on a minimum of 3,000 fixtures per month.

*Personnel.*—The duties and functions of the various members of this suggested inspection organization are as follows:

*Engineer.*—The engineer is in complete charge of the inspection organization. He supervises the layout of the work, the writing of the finished reports, the making of the finished drawings and the filing and cataloging of all information. He arranges for the various inspections and assists in making recommendations for corrections.

*Assistant engineer.*—The assistant engineer directs and supervises the work of three junior engineers. He receives the field notes and writes the final report on the buildings inspected.

*Junior engineer.*—The junior engineer makes the actual field inspections under the supervision of the assistant engineer. He develops the field notes and sketches and makes all recommendations for corrections to his immediate superior.

*Typists and draftsmen.*—The typists and draftsmen under the supervision of the engineer and the assistant engineers make over the field notes and prepare the final reports.

The office force consists of the engineer, two assistant engineers, typists and draftsmen. The two assistant engineers divide their time between the office and the field. The field force will be composed of the six junior engineers.

As far as possible, each junior engineer will work as a separate field unit. In small buildings, one man can perform the inspection very handily; in larger buildings, the cooperation of two or more of the junior engineers and occasionally the assistant engineer may be necessary.

Due to the administrative duties required of the engineer in charge of the inspection organization, it will be advantageous for him to direct the inspection in such a manner that his time in the field is reduced to a minimum.

The qualifications of personnel included in this suggested organization deserve considerable attention. With the exception of the draftsmen and typists, the members of a survey group should have a technical education and training or experience in the public health field. The training and education provided by accredited engineering schools permit the development of a more analytical insight into the problems encountered in work of this kind. Analysis of the factors influencing various fixtures and connections in a plumbing system plays an important part in arriving at satisfactory conclusions. The necessity for a knowledge of hydraulics, bacteriology, and sanitation and an understanding of the principles of the operation of certain mechanical devices makes an engineering education of vital importance. By benefit of training in the public health field, an engineer is capable of exhibiting a broader view or conception of the problem than is possible in one lacking that experience.

*Measurement of progress and efficiency.*—In order to make possible an estimate of the amount of work capable of being performed by this tentative survey organization in some unit other than the number of fixtures inspected per month, table X showing the number of fixtures per thousand square feet of floor space for various types of buildings has been included. This table has been compiled from the figures given in tables IV and VIII.

In making an estimate with the use of tables IX and X the completeness with which the survey is to be carried on must be given adequate consideration for this exerts a marked influence upon the number of fixtures inspected per month by the survey organization and upon a final estimate of their capabilities.

**Table X.**—*Number of fixtures per thousand square feet for various classifications of buildings, New York and Detroit*

| Type of building | Number of buildings | Floor area in square feet | Number of fixtures | Number of fixtures per thousand square feet |
|---|---|---|---|---|
| Residences | 293 | 1, 202, 104 | 3, 899 | 3. 2 |
| Dormitories, multiple-apartments, and barracks | 65 | 1, 140, 918 | 4, 129 | 3. 8 |
| Office buildings | 44 | 7, 644, 281 | 9, 550 | 1. 2 |
| Hospitals | 30 | 1, 119, 131 | 3, 109 | 2. 8 |
| Unclassified | 474 | 7, 911, 912 | 3, 977 | . 5 |
| Total | 906 | 19, 018, 346 | 24, 664 | 1. 3 |

# CHAPTER IV

## SPECIAL INVESTIGATIONS IN CONNECTION WITH THE PLUMBING SURVEY OF FEDERAL BUILDINGS

That more than a simple visual inspection of plumbing is often useful in a survey was demonstrated in the New York and Detroit work. In the final reports of the inspections no consolidation of the results of the investigation of various buildings in order to determine the hazard represented by the installation and use of defective plumbing fixtures in those buildings was attempted. There were several reasons for this but the principle one was the lack of information as to the frequency of occurrence of the factors influencing the danger presented by particular installations. The basis upon which a fixture was classed as approved or disapproved was solely the possibility of that fixture permitting the spread of contamination. The question as to how frequently contamination could be spread through the installation and use of a fixture was not considered. It is imperative, before a logical conclusion can be drawn from the results of any survey of this kind, that (1) the conditions which cause a fixture to be classified as hazardous, (2) the factors influencing these variable conditions, and (3) the frequency of occurrence of those factors be known.

Probably the most important and necessary factor required for the spread of contamination through a plumbing fixture or installation is the occurrence of a vacuum in the water line supplying the fixture. The devising of a means whereby all plumbing fixtures could be supplied with water under a positive pressure head at all times would eliminate the health hazard present in a majority of the disapproved fixtures in use today. The siphon breaker or vacuum breaker in use or on the market today is an attempt at this solution. The purpose of these devices is to prevent the vacuum from acting on the inlet to a fixture in such a manner as to eliminate the possibility of contaminated or waste material being siphoned into the water line.

A major condition necessary for classifying a plumbing fixture as a possible means for spreading contamination is that the water or liquid drawn back into the drinking water line when back-siphonage occurs be of a quality inferior to that of the water supplied to fix-

tures. Many excuses for the existence of interconnections have been made on the grounds that the water that might be drawn back into drinking water lines is not of a lesser quality than that of the water in those lines. An example of this is the use of water for cooling purposes in condensers where the water is intact in a closed piping system and the only change which takes place in it is a rise in temperature. The return of this water to the distribution system of a building or the existence of connections through which such a return would be possible are now considered dangerous. A noted example of the possible results of such a connection is explained in the description of the outbreak of amebic dysentery in Chicago in 1933. Another condition that has been accepted until recently as presenting little hazard to water quality, should back-siphonage occur, involves the tank-fed water closet. Under normal conditions the water in a toilet tank should not deteriorate in any way nor should its quality vary from that of the water existing in the supply line to the tank. However, unusual conditions may occur to cause contamination of the water.

## QUALITY OF WATER IN OVERHEAD TANKS

During the course of the plumbing survey in New York, a study was made of the bacteriological quality of the water in 20 overhead, open-top flush tanks in a comfort station.

In this study 211 samples were collected by trained personnel in accordance with good sampling technique and were tested within 2 hours after collection in a laboratory under the direction of a qualified bacteriologist to determine the number of bacteria per ml. growing on nutrient agar at 37° C. for 24 hours and the most probable numbers of coli-aerogenes group bacteria per 100 ml. The procedures followed were those given in Standard Methods of Water and Sewage Analysis of the American Public Health Association (8th edition, 1936) and the results were based on completed tests. The results of these tests are given in table XI. (For location of the various tanks see figure 17.)

In this series of tests, no control sample to indicate the quality of the incoming water could be secured at a point sufficiently close to the overhead tanks. In lieu of this, the best average result recorded for any tank has been used to indicate the poorest possible quality of the incoming water. This result is that of tank No. 7 which had an average total bacteria count per milliliter of 31 and an average M. P. N. (coli-aerogenes determination) of 0.8 per 100 ml. The assumption

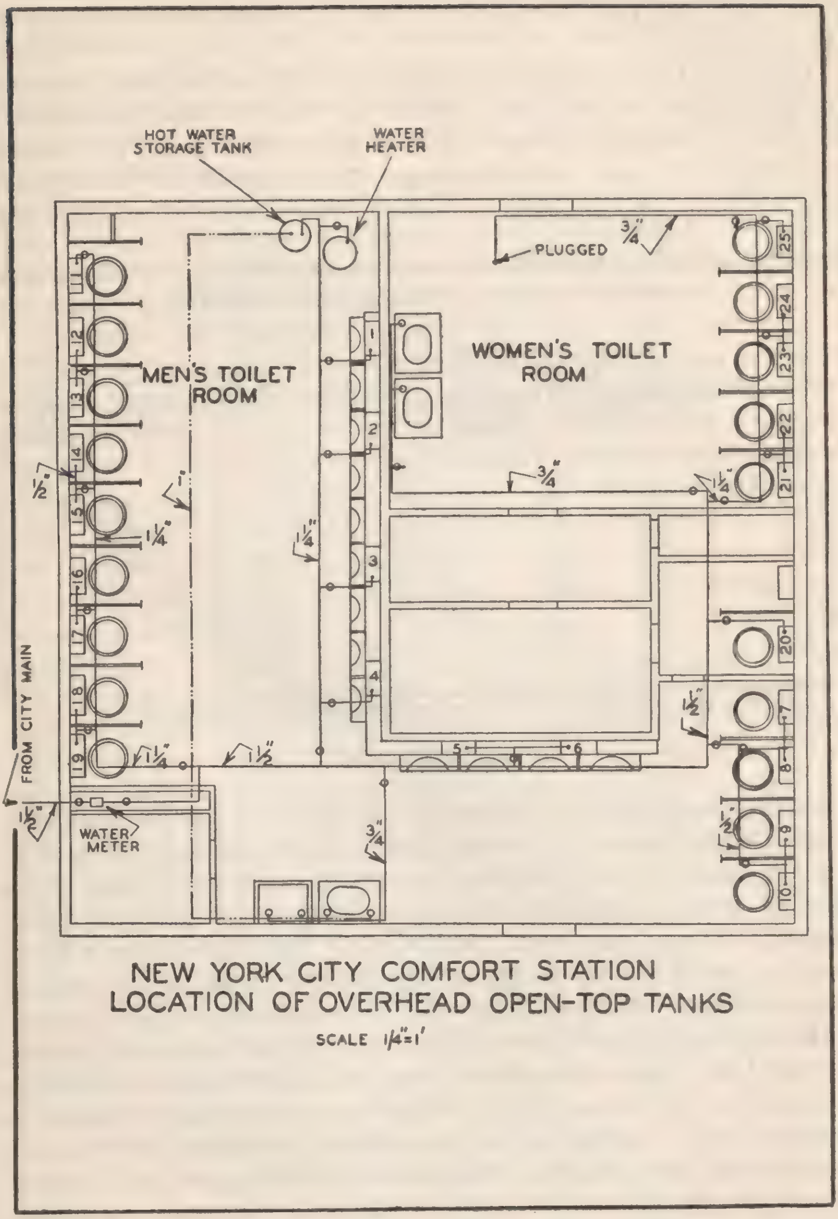


FIGURE 17.—New York City comfort station. Location of overhead open-top tanks.

that the quality of the incoming water was not of poorer quality than that contained in tank No. 7 is made possible by the fact that the 20 tanks were all supplied from the same source and with the same water and that the samples from all 20 tanks were collected at the same time.

Accepting the above assumption, it is therefore possible to state on the basis of the results listed in table XI that the water in the other 19 tanks investigated showed evidence of a deterioration in quality. Such being the case, back-siphonage of the contents of toilet tanks whether high or low, open or closed, should not be countenanced.

**Table XI.—*Results of bacteriological tests of water samples from 20 overhead, open-top tanks in a municipal comfort station***

| No. of tank | Number of samples taken | Average total bacterial count per milliliter [1] | Average M. P. N. coli-aerogenes determination [2] | No. of tank | Number of samples taken | Average total bacterial count per milliliter [1] | Average M. P. N. coli-aerogenes determination [2] |
|---|---|---|---|---|---|---|---|
| 1 | 11 | 11 | 2.4 | 12 | 11 | 8 | 3.1 |
| 2 | 13 | 49 | 5.2 | 13 | 11 | 13 | 3.0 |
| 3 | 11 | 81 | 4.3 | 14 | 11 | 25 | 2.8 |
| 4 | 11 | 72 | 1.2 | 15 | 11 | 1,355 | 2.7 |
| 5 | 11 | 28 | 5.7 | 16 | 11 | 18 | 2.4 |
| 6 | 11 | 68 | 3.5 | 17 | 5 | 17 | 3.3 |
| 7 | 11 | 31 | .8 | 18 | 5 | 14 | 3.7 |
| 8 | 11 | 16 | 3.0 | 19 | 13 | 10 | 4.6 |
| 9 | 11 | 9 | 24.4 | 20 | 10 | 1,870 | 2.8 |
| 10 | 11 | 10 | 3.7 | | | | |
| 11 | 11 | 10 | 1.7 | 20 tanks | 211 | 185 | 4.2 |

[1] Average total bacterial count per milliliter on agar at 37° C. for 24 hours.
[2] Average of the most probable number of coli-aerogenes group bacteria per 100 milliliters.

## FILTER STUDY

Another application of laboratory facilities to the determination of the deterioration of the water supply quality through the installation and use of certain plumbing fixtures was in a study made of the effect of certain small stone filters on the bacterial count of water passing through them (*131*). A total of 55 tests were run on 8 filters and the results indicated an average influent count of 51 and an average effluent count of 861 per ml. or an increase of 1,588 percent.

The conclusion drawn from this study was that the water passing through these filter stones leaves most of its undissolved substances on the stones' surfaces. These substances, apparently, are organic in nature as well as inorganic and provide any included bacteria with an abundant food supply. Multiplication takes place, and eventually, if the stone is not replaced or cleaned, it becomes completely impregnated with bacteria. After that condition is reached, the filter stone gives off to the water passing through it more bacteria than it removes.

## VACUUM FREQUENCY STUDY

Both of the preceding studies pertain to the deterioration of water quality through the installation and use of certain plumbing fixtures. Another study of interest is an investigation made subsequent to the completion of the plumbing inspection survey in New York. It was designed to determine the frequency with which a vacuum occurred or could be expected to occur in the water distribution systems of various buildings.

Since no data were available on the vacuum frequencies of buildings, a series of tests were run on six office buildings in New York to determine this information for these buildings and, also, to set up a method of procedure that might be followed in similar investigations of other buildings.

The plan first adopted in this study was to install an automatic pressure-vacuum recording gage at points in the buildings which were considered most likely to evidence a vacuum. Twenty-four hour pressure charts were obtained for each day until a vacuum was observed. It was soon realized that this procedure had certain definite limitations. In some buildings in which the gage was installed no vacuum was recorded even after a period of over 2 months. A procedure which required the investigation of each building for periods of 2 months or more was definitely out of the question. Also, if a vacuum was observed to occur at some time in the building, the interval of time from the installation of the gage to the occurrence of the vacuum could be determined, but no record could be obtained for the interval of time between the occurrence of the vacuum that was recorded on the chart and the occurrence of the previous vacuum in that building. Therefore, the scheme of work was modified to permit the installation of the gage for a predetermined period of time, the length of which would determine the accuracy of the result obtained. The charts from the building would then be used in developing a rough statistical analysis which would give an approximation of the actual vacuum frequency. This analysis consisted of tabulating, in order of magnitude, the lowest pressure recorded on the chart for each 15-minute interval during the 24 hours. The frequency with which each pressure was recorded was determined and the percent of the observed pressures that were less than each stated pressure was calculated. This percentage was then plotted on both arithmetic and logarithmic probability paper against the values of the pressures observed in pounds per square inch. The extension of the curve obtained to intersect the line of 1 pound of pressure will give an approximation of the frequency of occurrence which can be expected for a pressure of less than 1 pound. Since it is possible to read

only to the nearest pound of pressure on the gage charts and in order to read comparable results from the logarithmic plots (the logarithm of zero being minus infinity), a pressure of less than 1 pound has been considered to mean a pressure of zero or less pounds per square inch. The frequency of this occurrence has been considered as the vacuum frequency of the building, although it is really the frequency with which a vacuum can be expected to be recorded in a series of consecutive 15-minute low points.

To permit a better understanding of the results of the various plots, the results obtained from the extension of the curves on arithmetic probability paper have been converted so that the length of time required in each building (in days) for a pressure of less than 1 pound per square inch to be recorded is given. This conversion permits a more understandable comparison between the results from the various buildings.

The procedure outlined above, while subject to several limitations, has the advantage of producing an approximation of the actual vacuum frequency that is based on scientific fact rather than pure conjecture. It also has the advantage of being simple in application and of not requiring a too extensive period of time for completion.

In applying this method of procedure it must be remembered that the vacuum frequency obtained is for the point in the plumbing system at which the gage is installed. By installing the gage at a point in a building at which a vacuum is most likely to occur, it is assumed that the vacuum frequency obtained at this point will represent the maximum vacuum frequency for the building. In other words, a vacuum will not occur more often in any other part of the building than it will at the point selected.

The six buildings used for this study are referred to here as buildings A, B, C, D, E, and F, the essential characteristics of which have been listed in table XII. They were selected because of accessibility, convenience of location, and dissimilarity of distribution systems.

The length of time that the gages were installed in the six buildings studied was much longer than was contemplated for the modified procedure already outlined for the reason that a more complete and more accurate survey was desired. The time of installation varied in the six buildings from 2 weeks to over 2 months depending upon the building and the conditions observed. In several cases it was not possible to place the gage at the exact point desired because of limitations due to continuous operation of the buildings.

FIGURE 18.—TYPICAL PRESSURE GAGE INSTALLATION.

Table XIII shows the results as picked off the charts and arranged for plotting the curves on both arithmetic and logarithmic probability paper. The plots of the curves for the various buildings on arithmetic probability paper are shown on figures 19–24. It will be noticed that no consideration has been paid to any of the points plotted on the charts except those at the lower end of the pressure scale. This has been done because no interest is attached to the upper end of the scale, the extension of the lower end being all that is required.

Table XII.—*Essential characteristics of buildings included in vacuum study*

| Name of building | Height of building | Floor area in square feet | Number of supply mains | Size of supply mains | Average water pressure at meter in pounds per square inch | Type of distribution system |
|---|---|---|---|---|---|---|
| A | 12 stories and basement. | Approximately 75,000. | Unknown | Unknown. | Unknown | Overhead tank on roof, complete downfeed system, tank 30 feet above roof. |
| B | 5 stories, basement, and subbasement. | 319,712 | 2 | 4-inch | 40 | Upfeed from hydropneumatic tanks in basement. (90 pounds pressure from tank in daytime and 40 pounds pressure at night.) |
| C | 33 stories and basement. | 655,787 | 2 | 6-inch | 50 | Downfeed system from tank on thirty-third floor to all floors except basement. |
| D | 8 stories, basement, and subbasement. | 142,500 | 2 | 3-inch | 55–60 | Downfeed system from tank on roof for second to eighth floors, inclusive. |
| E | 8 stories, basement, and 2 penthouses. | 40,000 | 2 | 2-inch | 50–55 | Upfeed system to sixth floor; downfeed from roof tank to seventh, eighth, and penthouse floors. |
| F | 9 stories, basement, and subbasement. | Approximately 500,000. | 2 | 6-inch | Unknown | Downfeed system from tank on roof for third to ninth floors; upfeed to all other floors. |

**Table XIII.**—*Lowest pressures recorded in consecutive 15-minute intervals*

| Pressure (pounds per square inch) [1] | Frequency of occurrence | Cumulated frequency | Percent of observed pressures less than stated pressures | Pressure (pounds per square inch) [1] | Frequency of occurrence | Cumulated frequency | Percent of observed pressures less than stated pressures |
|---|---|---|---|---|---|---|---|
| BUILDING A | | | | | | | |
| 1 | 0 | 0 | 0.00 | 14 | 189 | 962 | 21.58 |
| 2 | 3 | 3 | .00 | 15 | 220 | 1,182 | 26.86 |
| 3 | 3 | 6 | .08 | 16 | 213 | 1,395 | 32.99 |
| 4 | 5 | 11 | .17 | 17 | 262 | 1,657 | 38.95 |
| 5 | 12 | 23 | .37 | 18 | 232 | 1,889 | 46.26 |
| 6 | 25 | 48 | .64 | 19 | 206 | 2,095 | 52.74 |
| 7 | 42 | 90 | 1.34 | 20 | 120 | 2,215 | 58.49 |
| 8 | 56 | 146 | 2.51 | 21 | 75 | 2,290 | 61.84 |
| 9 | 67 | 213 | 4.08 | 22 | 74 | 2,364 | 63.93 |
| 10 | 110 | 323 | 5.95 | 23 | 372 | 2,736 | 65.99 |
| 11 | 127 | 450 | 9.01 | 24 | 608 | 3,344 | 76.38 |
| 12 | 154 | 604 | 12.56 | 25 | 238 | 3,582 | 93.36 |
| 13 | 169 | 773 | 16.86 | | | | |
| BUILDING B | | | | | | | |
| −15 | 2 | 2 | 0.00 | 8 | 7 | 1,053 | 29.93 |
| −14 | 4 | 6 | .06 | 9 | 9 | 1,062 | 30.14 |
| −13 | 4 | 10 | .17 | 10 | 19 | 1,081 | 30.39 |
| −12 | 8 | 18 | .29 | 11 | 18 | 1,099 | 30.94 |
| −11 | 6 | 24 | .51 | 12 | 14 | 1,113 | 31.45 |
| −10 | 6 | 30 | .68 | 13 | 14 | 1,127 | 31.85 |
| −9 | 3 | 33 | .86 | 14 | 18 | 1,145 | 32.25 |
| −8 | 10 | 43 | .94 | 15 | 17 | 1,162 | 32.76 |
| −7 | 77 | 120 | 1.23 | 16 | 26 | 1,188 | 33.25 |
| −6 | 73 | 193 | 3.43 | 17 | 15 | 1,203 | 33.99 |
| −5 | 33 | 226 | 5.52 | 18 | 25 | 1,228 | 34.42 |
| −4 | 24 | 250 | 6.46 | 19 | 22 | 1,250 | 35.14 |
| −3 | 115 | 365 | 7.15 | 20 | 127 | 1,377 | 35.77 |
| −2 | 292 | 657 | 10.44 | 21 | 461 | 1,838 | 39.40 |
| −1 | 130 | 787 | 18.80 | 22 | 878 | 2,716 | 52.59 |
| 0 | 67 | 854 | 22.52 | 23 | 449 | 3,165 | 77.71 |
| 1 | 122 | 976 | 24.44 | 24 | 82 | 3,247 | 90.56 |
| 2 | 21 | 997 | 27.93 | 25 | 33 | 3,280 | 92.90 |
| 3 | 11 | 1,008 | 28.53 | 26 | 44 | 3,324 | 93.85 |
| 4 | 12 | 1,020 | 28.84 | 27 | 42 | 3,366 | 95.11 |
| 5 | 12 | 1,032 | 29.18 | 28 | 69 | 3,435 | 96.31 |
| 6 | 7 | 1,039 | 29.54 | 29 | 11 | 3,446 | 98.28 |
| 7 | 7 | 1,046 | 29.73 | 30 | 49 | 3,495 | 98.63 |
| BUILDING C | | | | | | | |
| 24 | 1 | 1 | 0.00 | 29 | 37 | 584 | 78.48 |
| 25 | 25 | 26 | .14 | 30 | 27 | 611 | 83.79 |
| 26 | 133 | 159 | 3.73 | 31 | 6 | 617 | 87.66 |
| 27 | 293 | 452 | 22.81 | 32 | 25 | 642 | 88.52 |
| 28 | 95 | 547 | 64.85 | 33 | 55 | 697 | 92.11 |
| BUILDING D | | | | | | | |
| −1 | 2 | 2 | 0.00 | 17 | 43 | 806 | 19.80 |
| 0 | 6 | 8 | .05 | 18 | 39 | 845 | 20.91 |
| 1 | 26 | 34 | .21 | 19 | 29 | 874 | 21.92 |
| 2 | 96 | 130 | .88 | 20 | 28 | 902 | 22.69 |
| 3 | 106 | 236 | 3.37 | 21 | 24 | 926 | 23.40 |
| 4 | 52 | 288 | 6.12 | 22 | 21 | 947 | 24.03 |
| 5 | 36 | 324 | 7.47 | 23 | 23 | 970 | 24.57 |
| 6 | 21 | 345 | 8.40 | 24 | 17 | 987 | 25.17 |
| 7 | 24 | 369 | 8.95 | 25 | 29 | 1,016 | 25.61 |
| 8 | 16 | 385 | 9.59 | 26 | 27 | 1,043 | 26.36 |
| 9 | 29 | 414 | 9.99 | 27 | 31 | 1,074 | 27.06 |
| 10 | 40 | 454 | 10.74 | 28 | 28 | 1,102 | 27.87 |
| 11 | 35 | 489 | 11.78 | 29 | 31 | 1,133 | 28.59 |
| 12 | 51 | 540 | 12.68 | 30 | 55 | 1,188 | 29.40 |
| 13 | 59 | 599 | 14.01 | 31 | 71 | 1,259 | 30.82 |
| 14 | 59 | 658 | 15.55 | 32 | 85 | 1,344 | 32.67 |
| 15 | 54 | 712 | 17.07 | 33 | 145 | 1,489 | 34.87 |
| 16 | 51 | 763 | 18.48 | 34 | 154 | 1,643 | 38.64 |

[1] Pressures preceded by a minus sign are negative pressures and are expressed as inches of mercury vacuum; 1 inch of mercury being equal to 0.4912 pounds per square inch.

Table XIII.—*Lowest pressures recorded in consecutive 15-minute intervals*—Continued

BUILDING D—Continued

| Pressure (pounds per square inch) | Frequency of occurrence | Cumulated frequency | Percent of observed pressures less than stated pressures | Pressure (pounds per square inch) | Frequency of occurrence | Cumulated frequency | Percent of observed pressures less than stated pressures |
|---|---|---|---|---|---|---|---|
| 35 | 206 | 1,849 | 42.63 | 45 | 142 | 3,513 | 87.47 |
| 36 | 222 | 2,071 | 47.98 | 46 | 143 | 3,656 | 91.15 |
| 37 | 201 | 2,272 | 53.74 | 47 | 91 | 3,747 | 94.86 |
| 38 | 189 | 2,461 | 58.95 | 48 | 59 | 3,806 | 97.22 |
| 39 | 168 | 2,629 | 63.85 | 49 | 27 | 3,833 | 98.75 |
| 40 | 161 | 2,790 | 68.21 | 50 | 12 | 3,845 | 99.45 |
| 41 | 143 | 2,933 | 72.39 | 51 | 6 | 3,851 | 99.77 |
| 42 | 149 | 3,082 | 76.10 | 52 | 2 | 3,853 | 99.92 |
| 43 | 150 | 3,232 | 79.97 | 53 | 1 | 3,854 | 99.99 |
| 44 | 139 | 3,371 | 83.86 | | | | |

BUILDING E

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0.00 | 13 | 90 | 497 | 20.94 |
| 2 | 2 | 2 | .00 | 14 | 170 | 667 | 25.58 |
| 3 | 4 | 6 | .10 | 15 | 194 | 861 | 34.32 |
| 4 | 10 | 16 | .31 | 16 | 191 | 1,052 | 44.24 |
| 5 | 23 | 39 | .82 | 17 | 214 | 1,266 | 54.12 |
| 6 | 45 | 84 | 2.01 | 18 | 91 | 1,357 | 65.12 |
| 7 | 52 | 136 | 4.32 | 19 | 100 | 1,457 | 69.80 |
| 8 | 47 | 183 | 7.00 | 20 | 85 | 1,542 | 74.95 |
| 9 | 36 | 219 | 9.41 | 21 | 232 | 1,774 | 79.32 |
| 10 | 46 | 265 | 11.27 | 22 | 132 | 1,906 | 91.25 |
| 11 | 69 | 334 | 13.64 | 23 | 37 | 1,943 | 98.04 |
| 12 | 73 | 407 | 17.18 | 24 | 1 | 1,944 | 99.99 |

BUILDING F

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.00 | 8 | 16 | 33 | 0.65 |
| 1 | 1 | 1 | .00 | 9 | 51 | 84 | 1.28 |
| 2 | 0 | 1 | .00 | 10 | 322 | 406 | 3.27 |
| 3 | 6 | 7 | .04 | 11 | 576 | 982 | 15.81 |
| 4 | 6 | 13 | .27 | 12 | 450 | 1,432 | 38.21 |
| 5 | 1 | 14 | .51 | 13 | 464 | 1,896 | 55.72 |
| 6 | 0 | 14 | .53 | 14 | 632 | 2,528 | 73.77 |
| 7 | 3 | 17 | .53 | 15 | 42 | 2,570 | 98.37 |

The results obtained by extension of the lower end of the curves are given in table XIV. The vacuum frequency is shown there as a percentage and is the same as read from the plots.

From the results in table XIV it is seen that in two of the buildings the frequency with which a vacuum might be expected to occur was not too small as to be insignificant. In fact, with the low pressures recorded in three of the buildings in which a vacuum was not actually observed to occur it is reasonable to assume, aside from any statistical analysis, that under more adverse conditions than were experienced during the period that the gage was installed, a vacuum might easily have been recorded. In only one building, C, can it be safely said that, under the conditions existing in the building at the time the study was made and the normal operating conditions of the water system, and excepting all unusual and unpre-

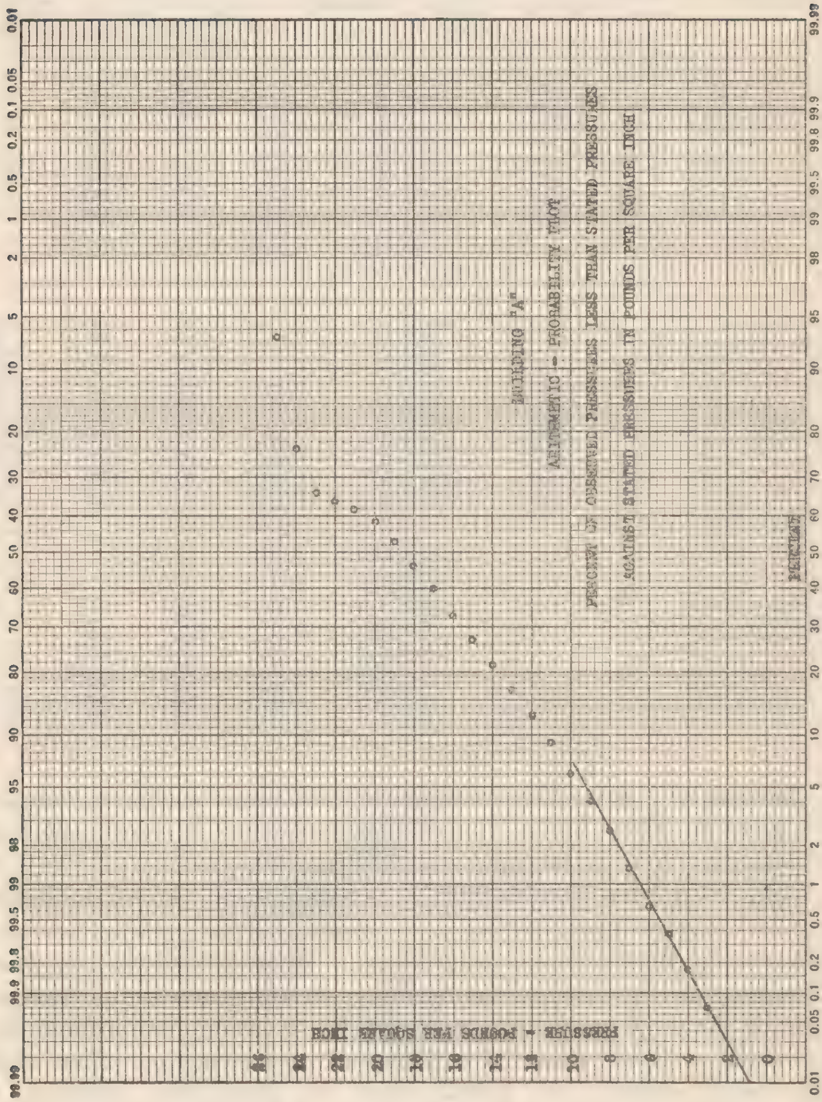


FIGURE 19.—Building A

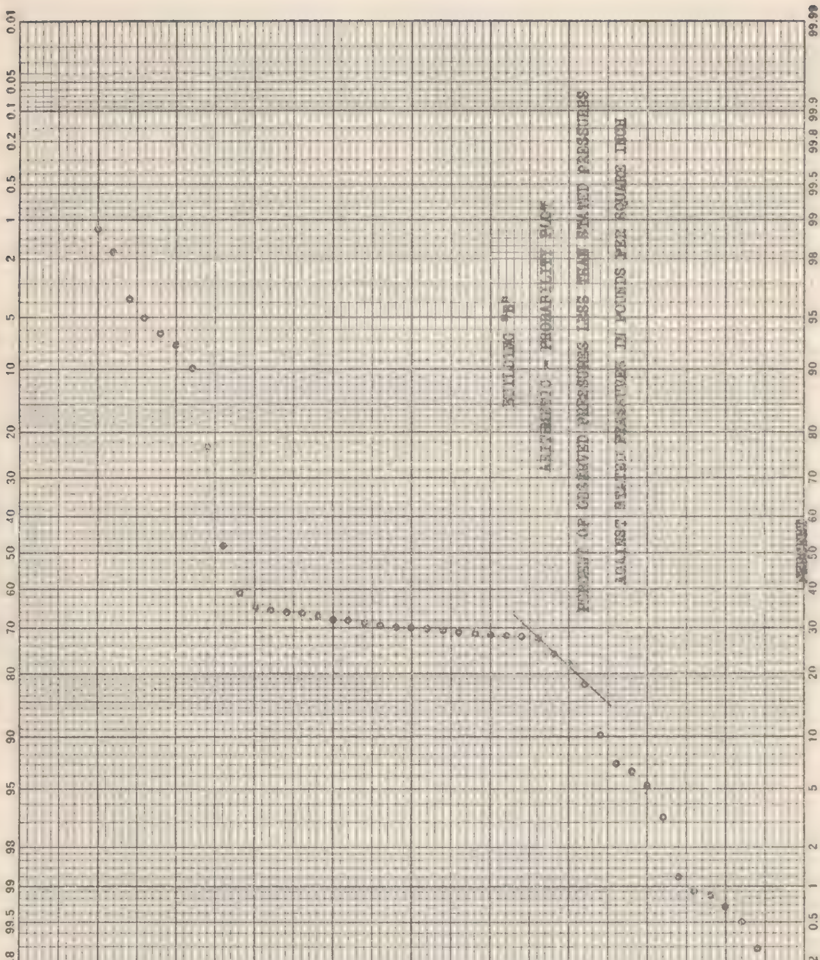

FIGURE 20.—Building B

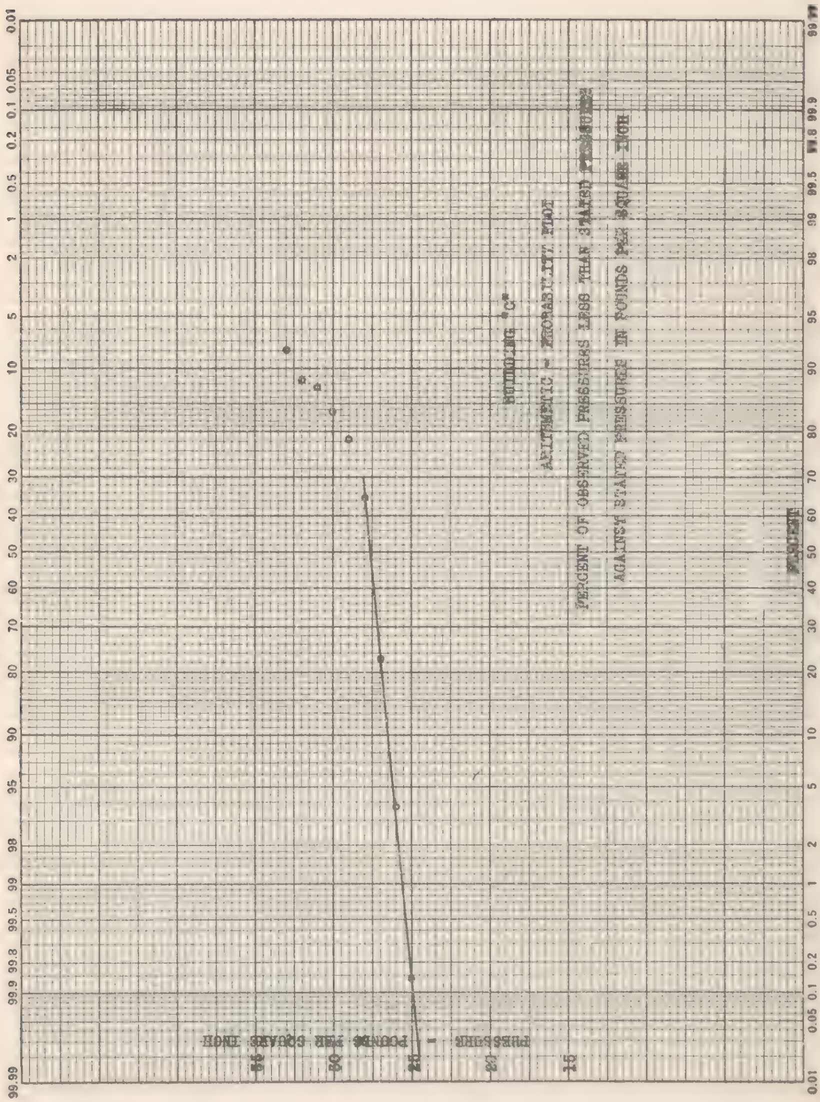


FIGURE 21.—Building C

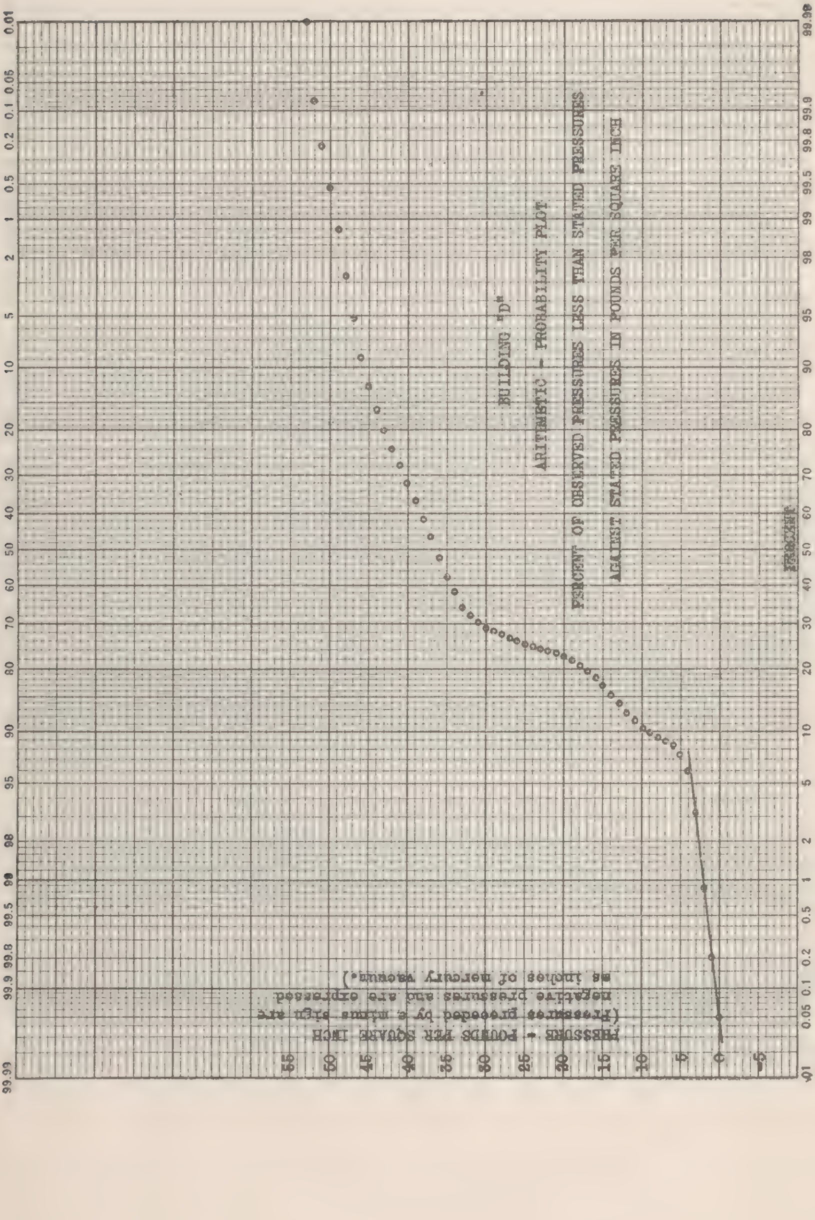


FIGURE 22.—Building D

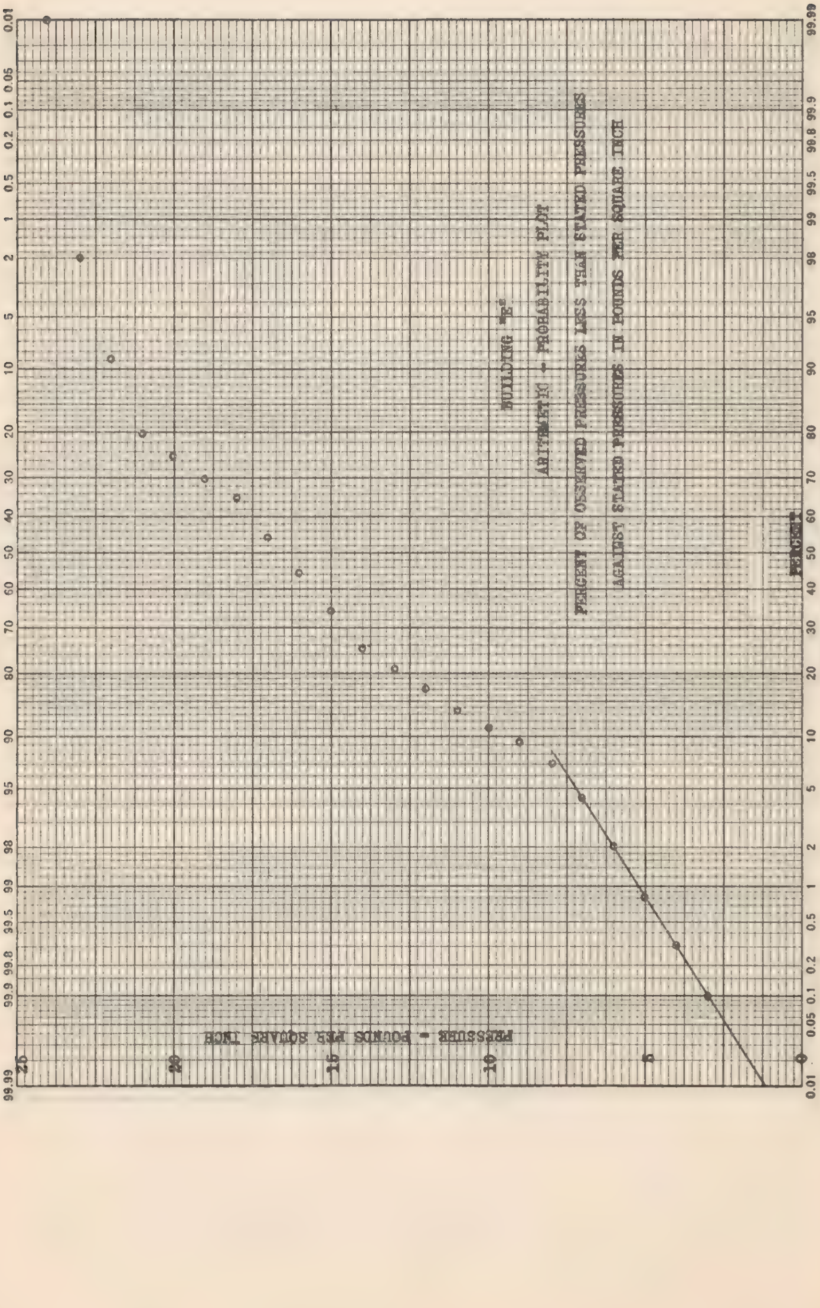


FIGURE 23.—Building E

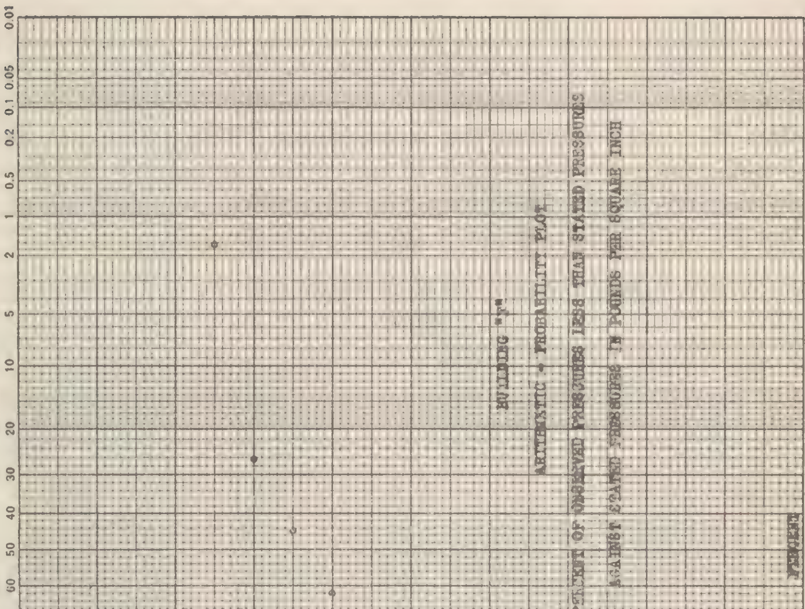


FIGURE 24.—Building I

dictable circumstances, such as breaking of pipes or draining of the distribution system, a vacuum might never be expected to occur. In the case of building B, a vacuum was observed to occur about 25 percent of the time. The reason for this high percentage can be seen by referring to a typical chart record of building B as shown in figure 25. The sustained vacuum during the night in this building was due to the shutting down of the house pumps as an economy measure. After the pumps were cut off, the pressure in the hydropneumatic tanks in the basement was gradually dissipated until it equalled the pressure from the street mains. This latter pressure was insufficient to keep the water in the vertical pipes up to the level of the fixtures on the fifth floor. As a result a sustained vacuum was created until the pumps were again turned on.

**Table XIV.**—***Results of study of vacuum frequencies of 6 New York office buildings***

| Name of building | Number of observations | Lowest recorded pressure | Vacuum frequency [1] (percent) | | Vacuum expectancy [2] |
|---|---|---|---|---|---|
| | | | From arithmetic-probability plot | From logarithmic-probability plot | |
| A | 3, 582 | 2 pounds per square inch | 0. 013 | 0. 0037 | 80 days. |
| B | 3, 495 | 15 inches of mercury vacuum | 25 | 25 | 0.042 days. |
| C | 697 | 24 pounds per square inch | Negligible | Negligible | Incalculable. |
| D | 3, 854 | 1 inch of mercury vacuum | 0. 24 | 0. 23 | 4.2 days. |
| E | 1, 944 | 2 pounds per square inch | 0. 0051 | 0. 0021 | 210 days. |
| F | 2, 570 | 1 pound per square inch | 0. 015 | 0. 0038 | 70 days. |

[1] The vacuum frequency recorded here represents the percent of time that a pressure of less than 1 pound per square inch could be expected to be recorded in a series of lowest pressures obtained from consecutive 15 minute intervals.

[2] The vacuum expectancy is the expected length of time (in days) required for a pressure of less than 1 pound per square inch to be recorded in a series of lowest pressures obtained from consecutive 15 minute intervals.

From the results of this survey it is evident that if building B contained the same number of defective plumbing fixtures of the same or similar type as did building C, then the hazard presented by these fixtures in building B would be very much greater than that presented by the same fixtures in building C. In other words, using the results of this study as a criterion, the fixtures in building B represent an almost constant menace to the purity of the water in the building, whereas the fixtures in building C present a negligible hazard. The other buildings studied in this survey grade themselves between these two extremes.

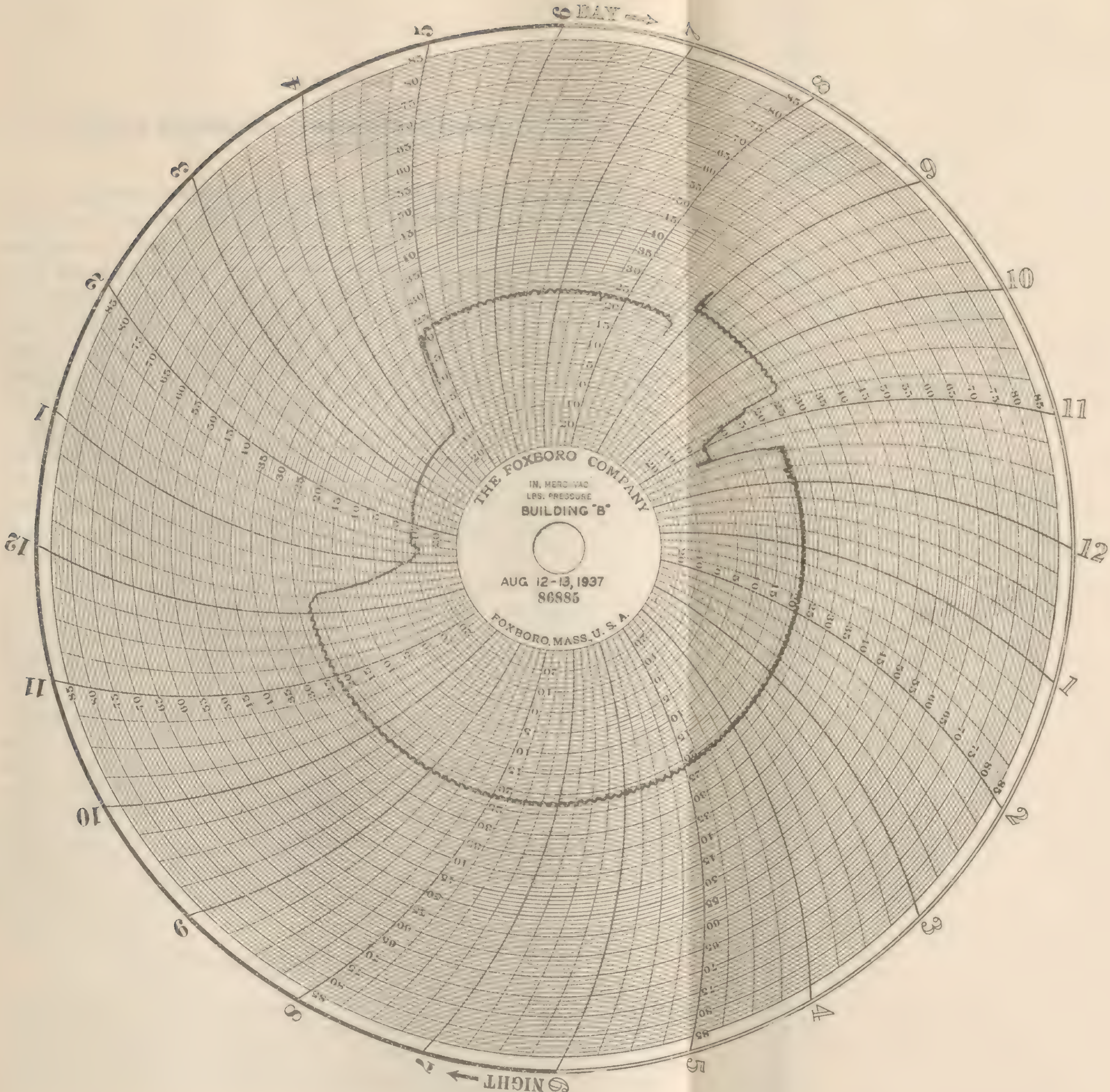


FIGURE 25.—Building B. Typical pressure chart.

# CHAPTER V

## SUGGESTED METHOD OF COMPARING RESULTS OF PLUMBING INSPECTIONS

The project described in chapter III contributed a large volume of information on the conditions of the plumbing fixtures and installations in use in the buildings covered. There is a lack, however, of a suitable method for comparing the hazard presented by the plumbing of one building with that of others. This chapter has been devoted, therefore, to the development of a tentative method of rating the plumbing in buildings in order that a more accurate and comprehensible comparison may be made between individual buildings or between buildings and an arbitrary standard.

The method of rating suggested here should not be construed as furnishing a superlatively exact figure for each building considered, for, like most rating schemes, the basic figures depend upon the judgment of the inspecting official. Further, this rating device must be tentative until frequent application either justifies it or indicates valuable and useful modifications.

As already stated, the accuracy of this proposed rating system is very closely related to the judgment of the one making the inspection. Therefore, in its application, comparisons should be made between results secured by individuals within the same organization. Only in this way can it be expected that errors of or variations in judgment will be at a minimum. If the results secured by working groups in two or more different cities are to be compared, the procedures of inspection used in those locations should first be standardized. The results from the use of this plan in a group all of whom have been trained together should be in close agreement. Despite these shortcomings, the rating method suggested herewith merits consideration as it furnishes a useful means of comparing the results of several plumbing inspections, an aid which up to now has not been available.

### TENTATIVE PLUMBING INSPECTION RATING SYSTEM

*Building hazard rating.*—Each building inspected shall be given a numerical rating indicative of the hazard presented by all of the plumbing fixtures and installations in place and in use in the building. This rating may be known as the building hazard rating. Any in-



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crease in the numerical value of the rating shows an increase in the hazard presented.

The building hazard rating may be determined by the following empirical formula:

$$B=KFDP$$

where:

$B$=Building hazard rating
$K$=1,000
$F$=Fixture hazard rating
$D$=Distribution system hazard rating
$P$=Pressure hazard rating

Each of the above three complementary ratings ($F$, $D$, and $P$) will depend upon the investigations and conclusions of the organization making the inspections and each will have a definite upper limit. Any rating above any upper limit will cause the entire building to be classed as unsatisfactory. The limiting standards used herein have been established for illustrative purposes only and should not be accepted as applicable to all future work. It is recognized that it will be preferable for each organization conducting work of this kind to establish its own limits to conform to a factor of safety previously decided upon. This would in no way affect this rating scheme except to change the mathematics of the computations.

The constant $K$ in the above formula is set at a value of 1,000 only to add significance to the final product. It is an arbitrary figure and has no bearing on the various ratings.

*The fixture hazard rating* ($F$) of a building shall be the average of the ratings for each separate fixture and plumbing installation in the building and may be expressed empirically as:

$$F=\frac{\Sigma(nf)}{\Sigma(n)}$$

where:

$F$=Fixture hazard rating.
$n$=number of each type of fixture.
$f$=individual fixture hazard rating.

These separate fixture ratings will depend upon the design and the use of each fixture or connection. The numerical value of the rating given each fixture shall be determined by the inspector making the examination in accordance with the following limitations:

| *Degree of hazard* | *Fixture rating* ($f$) |
|---|---|
| None | 0 |
| Remote | 0–5 |
| Potential | 5–10 |
| Definite | 10–20 |
| Serious | 20–50 |
| The existence and use of the fixture presents a menace so to require correction upon detection | above 50 |

In connection with the fixture ratings, the existence in a building of one or more separate fixtures or connections having a rating of more than 50 shall be considered sufficient cause to classify the condition of the plumbing in the building as unsatisfactory. Also, a fixture hazard rating ($F$) for the entire building in excess of 10 shall be sufficient cause to classify the building as unsatisfactory as to plumbing.

In arriving at the numerical ratings to be given to each separate fixture, a siphon jet water closet supplied through an unstable flush valve (a flush valve, the opening of which is facilitated by the occurrence of a vacuum in the supply line to the valve) unprotected by either check valve or siphon breaker would be given a hazard rating ($f$) of 10. All other fixtures are graded accordingly.

The *distribution system hazard rating* ($D$) defines in figures the condition of the water piping system of a building, the method of operation and maintenance of the distribution system, the type of system in use and the adequacy of its design. This rating should be made by the official in charge of the investigations and should be based upon his knowledge of the conditions in the building and his observations of the method of operation and maintenance of the distribution system. The numerical value for ($D$) may vary between 1 and 5. A value of 1 for a building indicates that the distribution system is free from any defects either in design, condition, maintenance, or operation, while a value of 5 shows a distribution system so poorly designed, maintained or operated as to warrant its classification as unsatisfactory.

The small numerical range allowed an inspector in rating the distributing system has the advantage of simplifying the task and, also, of reducing the effects of any errors in judgment on his part in grading the system.

The *pressure hazard rating* ($P$) of a building shall express the maximum frequency with which a vacuum may occur in any part of the building; such frequency being determined by the method explained in chapter IV or one similar to it. A value for ($P$) of 0.001 has been set up as the maximum vacuum frequency permitted without causing the plumbing of the entire building to be classed as unsafe. This figure is obviously an arbitrary one and it should be established only after careful consideration of all related factors by each organization undertaking surveys.

It has been shown by other investigators in this field that the existence of plumbing fixtures and connections in a building of only approved design will preclude any possibility of contamination being transmitted or spread through the plumbing system. In such a case, the application of this method of rating would indicate a fixture hazard rating ($F$) of zero. This rating when multiplied by the dis-

tribution system hazard rating ($D$) and the pressure hazard rating ($P$) will give a building hazard rating ($B$) of zero which would indicate that the plumbing system of the building was entirely free of any health hazards.

In the distribution system of a building, inadequate design and poor physical condition, operation, and maintenance all influence the degree of hazard attached to any defective plumbing fixtures found in a building. The improper location of pipes and plumbing equipment, i. e., the location of soil or waste lines above open drinking-water tanks, often present a considerable amount of danger. The effect of any defects in the distribution system is accounted for in the rating given it by the inspector. In the possible case of a building containing a distribution system of such design, condition, operation, type, and maintenance that it presents no hazard in itself and its influence due to its relation to fixtures is negligible, the distribution system hazard factor ($D$) would be 1. This, when multiplied by the other two ratings affecting the building hazard rating, would have no effect on the final product.

The third separate rating, the pressure hazard rating ($P$), is based on the vacuum frequency in the building. Since the majority of defective fixtures require the occurrence of a vacuum in the supply line to the fixture before back-siphonage can take place, the frequency with which that occurs modifies the hazard presented by the fixture. If the vacuum frequency is low, the hazard is low and vice versa. An apparent objection to the pressure-hazard rating exists in the case of a building in which the vacuum frequency is extremely low and in which there are one or more fixtures through which contamination may be spread without the necessity for a vacuum to occur. This difficulty can be surmounted only by giving it special consideration. However, the small number of these fixtures as compared with the number of those which do need a vacuum to make them hazardous does not warrant any deviation from the formula devised.

## APPLICATION OF SYSTEM

To illustrate how the plumbing inspection rating method just described may be applied to various buildings, five of those used in the vacuum study explained in chapter IV have been rated and detailed examples of the rating procedure have been given for buildings B and C.

*Examples of calculation:* Building B. Total number of fixtures inspected, 216.

| Type of fixture | (n) | (f) | (nf) |
|---|---|---|---|
| Lavatories | 47 | 0 | 0 |
| Lavatories | 13 | 1 | 13 |
| Flushometer closets | 12 | 10 | 120 |
| High tank closets | 73 | 3 | 219 |
| Sinks | 7 | 0 | 0 |
| Sinks | 1 | 1 | 1 |
| Showers | 9 | 0 | 0 |
| Urinals | 29 | 3 | 87 |
| Slop sinks | 10 | 0 | 0 |
| Slop sinks | 1 | 3 | 3 |
| Drinking fountains | 5 | 5 | 25 |
| Tanks | 3 | 1 | 3 |
| Suction ejectors | 1 | 10 | 10 |
| Cooling jackets | 1 | 10 | 10 |
| Water line in sump | 1 | 10 | 10 |
| Hot water line drain | 1 | 5 | 5 |
| Wells | 2 | 20 | 40 |
| | $\Sigma(n)$ 216 | | $\Sigma(nf)$ 546 |

(*a*) Fixture hazard rating. $F=\frac{\Sigma(nf)}{\Sigma(n)}=\frac{546}{216}=2.5$

Condition of distribution system—poor.

Operation and maintenance—very unsatisfactory.

Adequacy of distribution system—fair.

Type of distribution system—upfeed.

(*b*) Distribution system hazard rating. $D=5.0$.

(*c*) Pressure hazard rating. $P$ (see results of vacuum study) $=$ 0.25.

(*d*) Building hazard rating. $B=KFDP=1{,}000\times2.5\times5.0\times0.25=$ 3,100.

Building C. Total number of fixtures inspected, 712.

| | | | |
|---|---|---|---|
| Lavatories | 268 | 1 | 268 |
| Flushometer closets | 273 | 10 | 2,730 |
| Sinks | 4 | 0 | 0 |
| Showers | 27 | 0 | 0 |
| Urinals | 77 | 10 | 770 |
| Slop sinks | 55 | 0 | 0 |
| Drinking fountains | 2 | 3 | 6 |
| Developing tanks | 5 | 5 | 25 |
| Photostat machine | 1 | 5 | 5 |
| | $\Sigma(n)$ 712 | | $\Sigma(nf)$ 3,804 |

(*a*) Fixture hazard rating. $F=\frac{\Sigma(nf)}{\Sigma(n)}=\frac{3{,}804}{712}=5.3$

Condition of distribution system—good
Operation and maintenance—good
Adequacy of distribution system—good
Type of distribution system—downfeed

(*b*) Distribution system hazard rating. $D=1.0$

(*c*) Pressure hazard rating. $P$ (see results of vacuum study) $=0.0000+$

(*d*) Building hazard rating. $B=KFDP=1.000\times 5.3\times 1.0\times 0.0000+=0.0000+$

Summarizing the ratings of the five buildings we have:

Table XV.—*Ratings of 5 New York office buildings*

| Building | F | D | P | B |
|---|---|---|---|---|
| B | 2.6 | 5.0 | 0.25 | 3100. |
| C | 5.3 | 1.0 | .0000+ | 0.0000+ |
| D | 1.8 | 2.0 | .0024 | 8.6 |
| E | 2.7 | 3.0 | .000051 | .41 |
| F | 3.3 | 1.0 | .00015 | .50 |

*Discussion of application.*—Upon examination of table XV, it is apparent that the hazard presented by the plumbing in building B is very much greater than that presented by any other building. An examination of the three component parts which make up the building rating ($B$) shows that the hazard presented by the fixtures ($F$) is less than the average for the five buildings. On the other hand, the distribution system hazard rating ($D$) and the pressure hazard rating ($P$) are both excessive. In contrast, the fixtures in building C, in themselves, present over twice the hazard as those in building B but the hazard surrounding the entire plumbing installation in building C is almost negligible. The reason for this is the extremely low vacuum frequency.

Another comparison of interest is supplied by table XVI where the five buildings have been arranged according to age.

Table XVI.—*Ratings of 5 New York office buildings by age of building*

| Age of building in years | Building | F | D | P | B |
|---|---|---|---|---|---|
| 72 | B | 2.6 | 5.0 | 0.25 | 3100. |
| 60 | D | 1.8 | 2.0 | .0024 | 8.6 |
| 51 | E | 2.7 | 3.0 | .000051 | .41 |
| 4 | C | 5.3 | 1.0 | .0000+ | .0000+ |
| 1 | F | 3.3 | 1.0 | .00015 | .50 |

Here it becomes evident that in the newest buildings the fixture hazard rating is appreciably higher than that for the older buildings. In other words, modern plumbing fixtures present more danger to the public health, in themselves, than do fixtures of a less recent design. On the other hand, the design and adequacy of operation and maintenance of the distribution system have been materially improved. This latter factor may also be the cause for the existence of a lower vacuum frequency in modern buildings. In any event, the combined effect of the three separate ratings is such as to indicate an increase in the safety of the plumbing in the newer buildings.

It may be contended that with the passage of several years, the distribution systems of the new buildings of today will present as great a hazard as those of the older buildings do at the present time. If such were the case, the new buildings of today would, in perhaps fifty years time, be a source of greater danger to the public health than the older buildings are now. It is believed, however, that the increasing knowledge of the principles of distribution system design and the factors causing systematic deterioration of those systems together with the very evident tendency to a closer control of plumbing systems to protect public health will preclude any appreciable increase in the hazard presented by the distribution systems in use today.

*Application of rating method to corrective measures.*—As a result of the publicity attending the results of the studies of the several investigators in plumbing and its relation to water supply quality and public health, a number of cities and states have enacted legislation designed to prohibit the future installation of defective plumbing fixtures. The value of such legislation in effecting the correction of certain types of fixtures is, up until the present time, unknown. The rating method explained in the first part of this chapter will, it is hoped, furnish a yardstick by which the relative value of correcting the various types of defects may be estimated and compared. To illustrate how this method may be used in estimating the value of certain corrective measures, the following examples are given.

It is assumed that it is required to change all flush-valve-supplied toilets in buildings so that complete protection against back-siphonage is provided. The question then is, "what effect will such a change have upon the hazard rating of any of the buildings studied?" Using building E for an example we find that it has the following ratings:

$$B=0.41$$
$$F=2.7$$
$$D=3.0$$
$$P=.000051$$

This building contains 27 water closets of the flush-valve type. Before change, each of these closets would have a rating of 10 and $(nf)$ would be 270. If complete protection is provided the $(nf)$ for the 27 water closets would be zero instead of 270. Deducting 270 from the $\Sigma\ (nf)$ of the building, 412, gives a new $\Sigma\ (nf)$ of 142. This divided by the building's $\Sigma\ (n)$, 150, gives a new $F$ of 0.95. Substituting in the formula for $B$:

$$B=1{,}000\ (0.95)\ (3.0)\ (.000051)=0.15$$

This represents a reduction in the hazard rating or an increase in the safety of the plumbing of the building of:

$$\frac{0.41-0.15}{0.41}\times 100=63\%$$

Therefore, the initiation of a measure requiring all water closets equipped with flush valves to be altered so as to furnish complete protection against back-siphonage, would cause the hazard represented by the plumbing in building E to be reduced 63 percent.

Another application of the rating method to corrective measures is in determining the most economical and suitable method of decreasing the hazard connected with the fixtures and installations in the building. For instance, from an examination of the ratings for building B it is evident from the fixture hazard rating, $F$, that the fixtures alone are not the cause of the high building rating. On the other hand, the high distribution system hazard rating, $D$, indicates that attention should be directed to a consideration of its adequacy and operation.

The rating method is useful also in determining the priority of corrective measures for the buildings covered. Fixing a building hazard rating limit which will serve to divide the inspected buildings into two groups; one, including those buildings which can be classed temporarily as satisfactory and the other, those which require corrective measures at once, should expedite the initiation and application of such measures. Such a limit will, in fact, define the margin of safety required for the plumbing installation in use and newly installed in buildings within the jurisdiction of the inspecting agency. For the five buildings rated in this discussion, a building hazard rating of 1.0 might be considered as the limit that is not to be exceeded if the buildings are to be temporarily classed as satisfactory. An examination of the ratings of the five buildings discloses that building B with a $(B)$ of 3,100 and building D with a $(B)$ of 8.6 would both be classed as unsatisfactory and in need of correction.

# CHAPTER VI

## CORRECTIVE MEASURES

The elimination of hazard-producing plumbing fixtures and appliances from future buildings will depend upon the availability of equipment of such design as to conform to rigid sanitary standards, adequate supervision of their installation to avoid mistakes and control of their employment to preclude misuse. The design of over-the-rim fixtures, so as to provide an air gap between the end of the inlet spout and the highest possible water level in the fixture of such dimensions as to make impossible the backflow of contaminated liquid or material under any condition of vacuum, has been studied by investigators in this field. Formulas for the size of air gap required for this type of fixture have been developed. Dawson gives for the minimum allowable air gap for over-the-rim fixtures, the following: $G=2D$ for circular openings and $G=2\frac{1}{4}\sqrt{A}$ for other type openings, where $G$ is the air gap in inches. $D$ is the diameter of the inlet in inches and $A$ is the minimum area of the inlet in square inches (*139*). This formula is convenient and provides for a factor of safety. Hunter et al. as a result of their experiments gives the following: $X=2.45\,d\left(1-0.26\frac{d}{D}\right)(1-0.28\,d)$ where $x$ is the required air gap in inches, $d$ the internal diameter, and $D$ the external diameter of the spout in inches. This formula holds true if local variations in atmospheric conditions are neglected. Hunter also recommends the reduction of the above formula to $x=1.8d$, for simplifying its application (*191*). Both of the investigators mentioned above have produced formula for the minimum air gap required to furnish full protection to over-the-rim fixtures against back siphonage which are essentially the same. Dawson's formula includes a larger factor of safety and is probably simpler to apply. Designing and installing fixtures of over-the-rim type in accordance with either of the above formula will preclude any possibility of back siphonage taking place through the fixture. That fixtures of this type are available is shown by the fact that the formula $G=2D$ was used in the plumbing survey in New York and Detroit as a basis upon which the over-the-rim type fixtures were approved or disapproved, and of 6,679 lavatories inspected in New York, 1,114 were found to be satisfactory.

In addition to improving the design of certain plumbing fixtures, adequate measures for the control and regulation of plumbing systems are required in order to safeguard against the installation and use of fixtures and connections which may create hazards. These can be had through the development and adoption of adequate plumbing codes which should provide for the regulation of the various persons engaged in building plumbing systems and of the material to be used, the latter to include sizes of pipes and types of connections allowed and prohibited. Only qualified workmen should be permitted to install or alter plumbing fixtures and then only after securing a permit from a duly constituted authority to do so. An inspection of the completed work should assist materially in reducing errors in work. The submission of plans of new work for review would permit the discovery of possible dangerous arrangements. The inclusion in plumbing codes of definite standards for the design and installation of plumbing fixtures should result in the establishment of a standardized and safe system of plumbing.

To correct existing defects, a survey organization for the discovery and location of them is desirable. Such an organization working with a method similar to that suggested in chapter V can locate and note the existence of plumbing defects and health hazards requiring immediate correction. By setting up limits defining the dividing line between safe and unsafe installations such an organization would be able to find those buildings and plumbing systems that are unsatisfactory and a menace to health. Requiring all existing installations to meet certain definite standards of safety would result in a lessening of the possibility of the spread of contamination through such fixtures and connections, and periodic reinspections by a survey organization would reduce the possibility of the conversion of a safe fixture to a potential hazard through alterations in the design of the fixture to meet the user's need.

Another method for obtaining the correction and elimination of defective and hazardous fixtures is through the development of an educational program for the dissemination of information on what constitutes a safe fixture and on the hazards of back-siphonage. Models, plumbing exhibits, motion pictures, and published articles are all examples of how information regarding plumbing hazards and their possible effect on water-supply quality may be spread.

Photographs of plumbing-code violations, poorly designed plumbing fixtures, and health hazards resulting from alterations in fixtures due to the nature of their uses are often helpful for educational purposes. In the course of the completion of the New York survey summarized in chapter III a number of photographs were taken of existing defects. These photographs illustrate a number of de-

FIGURE 26.—LAVATORY WITH DRAIN OUT OF WINDOW.

FIGURE 27.—HOT WATER TANK DRAIN LINE.


FIGURE 28.—DIRECT DRAIN AND OVERFLOW CONNECTION.

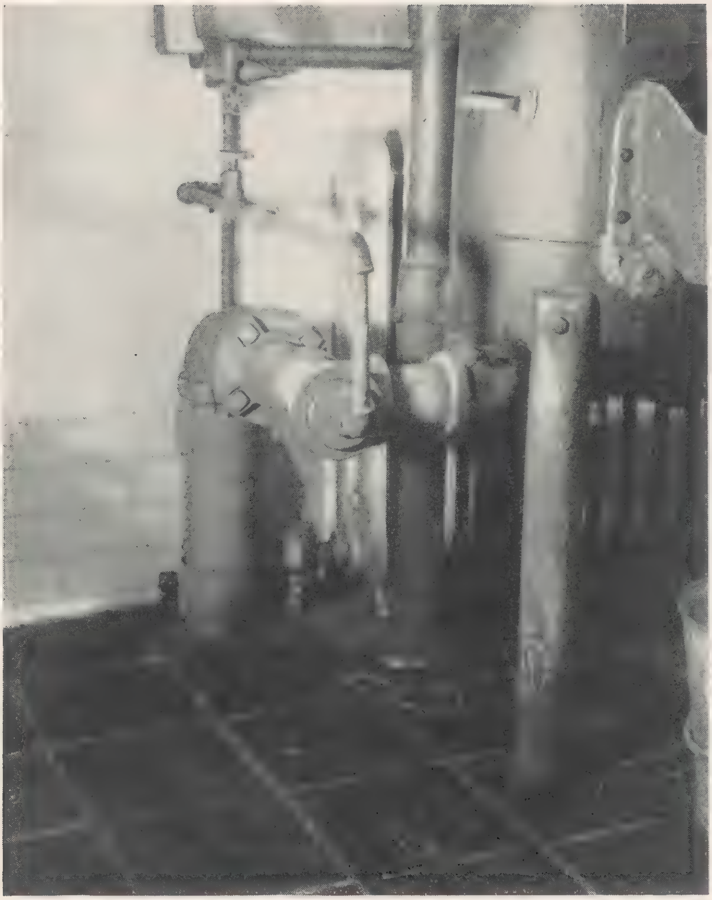

FIGURE 29.—POTATO PEELER INTERCONNECTION.

FIGURE 30.—SUBMERGED HOSE IN SINK.


FIGURE 31.—WATER-SOIL LINE INTERCONNECTION

ficiencies ranging from minor code violations to serious health hazards. Figures 26 to 28 illustrate the results of unsupervised plumbing installations. In Figure 26 the photograph shows a lavatory installed in a most unworkmanlike manner. The drain from the fixture instead of being connected to a waste stack and discharging into the house drainage system has been run out of a second-story window and discharges upon the ground next to the building.

Figure 27 shows another unsatisfactory installation. In this case the drain from the bottom of the hot-water tank (end just visible at the left side of the picture), runs along the floor as shown and then turns up and connects into the drain line leading to the top of the trap. With the water-supply line shut off, any attempt to empty the tank through the drain line could easily result in sewage flowing into the tank rather than the water draining out, especially under conditions of stoppage or overloading in the soil stack. Another possibility of contamination exists as a result of this connection. The water-supply line to the tank enters at the bottom so that with a vacuum in the line the water would be drawn out of the tank together with any contaminated water or sewage that may be sucked out of the drain line through an open or leaky valve.

The main deficiency in a number of installations is the presence of a direct path through which contamination may pass from the waste or sewerage system into the water supply system. An instance of this defect is illustrated in Figure 28. Here there is shown three defective and potentially dangerous installations. The drain from four filters and the drain and overflow from the suction tank on the domestic supply system are all connected directly into the house drain. That any or all of these lines may be subject to a definite back pressure may be realized by noting the existence of the soil stack rising diagonally across the left corner of the photograph. The occurrence of a stoppage in the house drain at a point beyond these connections may permit sewage or waste water to back up in the soil stack and exert an increasing pressure on the drain valves and upon the check valve located in the overflow pipe. The existence of a direct connection between the house drain and the two drains and overflow previously mentioned will almost preclude the possibility of observing whether the valves are tight and not leaking. With an indirect connection to the house drain, the leaking of any of the valves would be immediately apparent.

All of the foregoing illustrated defects are the result of inadequate control over the installation of plumbing fixtures and connections. The requirement that plumbing fixtures be installed by qualified workmen fully cognizant of the hazards of faulty installations will preclude the occurrence of such eventualities.

The alteration of a plumbing fixture during its use is responsible for the existence of several common defects. In figure 29 a water line is shown connected into the waste line from a potato peeler. The purpose of this connection was to assist in flushing the potato peelings into the sewer. Should a vacuum occur on this water line together with an open or leaking control valve it would be possible for contaminated material to be drawn from the waste line back into the water supply.

Figure 30 illustrates another similar installation. In this case. a rubber hose has been connected to the cold water faucet of a general utility sink. The purpose of it was to assist the porter in cleaning cuspidors. The dangerous feature of this installation is the fact that when not in use, the end of the hose is allowed to rest on the bottom of the sink and occasionally may be submerged in the sink contents. Such a condition is illustrated in the picture. Should a vacuum occur on the water line under these conditions and should the inlet valve be opened or leaking it would be possible for a portion of the contents of the sink to be drawn into the water line.

Another illustration of a man-made interconnection is shown in figure 31. In this case, a 2-inch water line has been connected into a 6-inch soil line. The soil line discharges into a tidal bay below the high-water level. As a result it is occasionally subject to stoppages. The purpose of the water line, therefore, was to furnish a stream of water to the soil pipe to flush out any deposited material. If a vacuum were to occur on the water line or if the pressure in the soil line were to become greater than the water pressure and the valve was open or leaking, contamination of the water supply would be apt to result.

All of the preceding illustrations indicate the necessity for a complete inspection of the plumbing of both existing buildings and buildings constructed in the future. The need for occasional reinspections of existing buildings is manifested by the illustrations shown in figures 29 to 31. In spite of the fact that plumbing fixtures may be of approved design when first installed, the nature of their use may result in changes and alterations in them such that the fixture may be converted into a public health hazard. Periodic reinspections plus a comprehensive educational program may be expected to do much toward the reduction in the number of such unethical alterations.

## CONCLUSIONS

Millions of dollars have been spent for the purpose of locating, developing, and supplying pure water to the public, and noteworthy advances have been made in the processes for the treatment and purification of water and for its ultimate distribution to the consumer.

The result has been a marked decrease in the number of cases of water-borne diseases. Spontaneous and sporadic outbreaks, however, of both mild and severe cases of intestinal disturbances have shown that the safeguarding of the water supply has been inadequate in certain respects. Connections have been made and fixtures and appliances installed and used that present a possible source of contamination of the water supply. The outbreak of amebiasis in Chicago in 1933 emphasized the dangers resulting from the installation and use of faultily designed plumbing and aroused much interest in this field resulting in renewed investigatory activity. Many phases of the subject have been covered including survey work, research on proper fixture design, initiation of corrective measures, and investigations into the availability of safe, sanitary plumbing fixtures. The direct result of all these studies has been an indication of the need for further inquiry into plumbing hazards as they exist in buildings in an effort to rationalize the hazard attributed to their installation and use. The lack of adequate means by which the hazard presented by the installation of defective plumbing fixtures may be determined has necessitated the development of a system whereby the results for various buildings may be evaluated and compared. This method of approach has been to reduce the findings of an inspection party to a numerical rating that is indicative of the amount of danger resulting from the installation and use of the defective fixtures and connections in each building. This has made possible a better conception of the dangers of various plumbing systems and connections and a more accurate correlation of the factors influencing the amount of hazard presented.

Justification for extended plumbing inspection is vouchsafed by the results obtained by the New York and Detroit survey of the Works Progress Administration and the United States Public Health Service. The location and correction of several separate installations having a very high hazard rating has indicated the existence of such dangers which, even though few in number, contribute considerably to the health hazard present in the plumbing systems in use today. The discovery and correction of these obscure but highly dangerous fixtures or connections may be assured only by a comprehensive investigation of all the plumbing systems installed and in use at the present time. Elimination and prevention of the installations of this type of fixture and connection in the future may be assured through a rigid control of the plumbing being installed in a building and through the education of plumbers, architects, engineers, and the public at large in the fundamentals of safe plumbing.

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# APPENDIX A

## SURVEY QUESTIONNAIRE

Name of building______________________ Date__________________________
Address_______________________________ Chief of party__________________
Description of building________________ Sanitary engineers______________
_____________________________________ _______________________________
____________________Age_______years _______________________________
______________________________________________________________________
Summary: Report of plumbing inspection, date__________________

DEFICIENCIES

| Cross-connections | Submerged supplies | Defective plumbing |
|---|---|---|
| Shore water________ | Bathtubs________ | Soil pipe________ |
| River water________ | Lavatories________ | Waste pipe________ |
| Used wells________ | Laundry washers________ | Vent pipe________ |
| Flush valves________ | Steam tables________ | House drain________ |
| Filter drains________ | Soup kettles________ | Miscellaneous________ |
| Filter back wash________ | Dish washers________ | ________ |
| Hydraulic elevation waste________ | Sinks________ | TANKS |
| Pump priming________ | Miscellaneous________ | Roof supply________ |
| Ice machine waste________ | ________ | Surge________ |
| Bypass________ | Drinking fountains disapproved________ | Open________ |
| Cooling jackets________ | | Wood cover________ |
| Swimming pools________ | ________ | Metal cover________ |
| Miscellaneous connections________ | ________ | Pressure________ |

CITY WATER SUPPLY

| | | |
|---|---|---|
| Number and size of meters | Fish traps______________ | Filtered______________ |
| ______________________ | Valved______________ | Treated______________ |
| ______________________ | Check valves__________ | Temperature________°F. |
| ______________________ | Condition______________ | Residual chlorine___ppm. |
| ______________________ | Pressure___________lbs. | Sample______________ |

| Average analysis of _______ samples | |
|---|---|
| B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | *Per cc.* |

Main feeder line: Size__________________ Termination ________________

BRANCHES FROM MAIN FEEDER

| Size | Service | Size | Service |
|---|---|---|---|
| Branch No. 1________ | ________ | Branch No. 5________ | ________ |
| Branch No. 2________ | ________ | Branch No. 6________ | ________ |
| Branch No. 3________ | ________ | Branch No. 7________ | ________ |
| Branch No. 4________ | ________ | Branch No. 8________ | ________ |

Are there any bleeders? ------ Valved ------ To where? ------------------
Cross connected with any other system ----------------------------------------
----------------------------------------------------------------------------------
Are there any lines dead or dead-ended ----------------------------------------
Sketch ---------------- Remarks ----------------------------------------

HOUSE PUMPS

Source of supply ------------------------ Temperature ---------------- °F.

| | Capacity | Suction pressure | Discharge pressure | Power | Type |
|---|---|---|---|---|---|
| | *Gallons per minute* | *Pounds* | *Pounds* | | |
| Pump No. 1 | | | | | |
| Pump No. 2 | | | | | |
| Pump No. 3 | | | | | |
| Pump No. 4 | | | | | |

NOTE.—(If from wells, give additional information under Well Water Supply.)
Are pumps primed? ------ From what source ----------------------------------
Are house pumps serving as standby for any other pumping unit? ------------
Detail ------------------------------------------------------------------------
----------------------------------------------------------------------------------
Any other source of supply to pumps? ------ Detail -------------------------
----------------------------------------------------------------------------------
What part of house is served by house pumps direct? ------------------------
What units are served by house pumps direct? -------------------------------
Are all house pumps directly connected with house tanks?-------------------
Can house tanks be shut off from pumps?-----------------------------------------
Are house pumps actuated by control from house tanks?---------------------
Sketch -------------------- Remarks -----------------------------------
----------------------------------------------------------------------------------

MISCELLANEOUS PUMPS

| | Type and kind | Purpose | Primed | Capacity | Discharge pressure |
|---|---|---|---|---|---|
| | | | | *Gals. per min.* | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |

Temperature--------------------° F.
Residual chlorine----------------ppm.
Sample --------------------------
----------------------------------
----------------------------------
Sketch ---------------------------
----------------------------------
----------------------------------

| Average analysis of ------ samples | | |
|---|---|---|
| Pump No. | B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | | *Per cc.* |
| | | |

Remarks ----------------------------------------------------------------
----------------------------------------------------------------------------------

HOUSE WATER SUPPLY

Source ----------------------------------------------------------------
(If from wells, see Well Water Supply).

Pressure ________________________lbs.
Temperature ____________________ ° F.
Residual chlorine _____________ppm.
Sample __________________________
_________________________________
Filtered _________________________
Treated _________________________

| Average analysis of ______ samples | |
|---|---|
| B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | *Per cc.* |
| ______ | ______ |
| ______ | ______ |
| ______ | ______ |

Are all bathrooms and toilets served by one water line in each shaft? ________ If two lines are used, is one line to flush valves on a separate tank? ______ Detail
_________________________________________________________________
Condition of piping ____________________ Valves ___________________________
Is house water supply cross connected with any other system? ________________
Sewers? ________ Tanks? ________ Drains? ________ Other? _________________
Are there any bleeders? ________ Valved? ________ to where _________________
_________________________________________________________________
What units are supplied? _________________________________________________
_________________________________________________________________
Are all discharges from units so arranged to prevent back pressure or syphonage?
_________________________________________________________________
Are any water lines drained to sewer? ______ Detail _______________________
_________________________________________________________________
What pumps have primer lines? ____________________________________________
Detail ___________________________________________________________
What pressure units have water connections? _________________________________
Detail ___________________________________________________________
Are any lines to units submerged? __________________________________________
Detail ___________________________________________________________
Are water inlets to air washers above pan? ___________________________________
Detail ___________________________________________________________
Are there any dead end lines? ______________________________________________
Sketch ________________ Remarks _____________________________________
_________________________________________________________________

HOUSE TANKS

No. ________ Kind ________ Cover ________ Kind _________________________
Capacity _____________________ Condition ___________________________________
Location __________________________________________________________
Height above street level __________ Overflow __________ to _______________
Inlet submerged ___________________ Drain ____________ to ______________
Sketch ________________ Remarks _____________________________________
_________________________________________________________________

Temperature _____________________ °F.
Residual chlorine _______________ ppm
Sample ____________________________

| Average analysis of ______ samples | | |
|---|---|---|
| Tank No. | B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | | *Per cc.* |
| ______ | ______ | ______ |
| ______ | ______ | ______ |
| ______ | ______ | ______ |

SURGE TANKS

NOTE.—If more than one tank, use separate sheet for each tank.

Size __________ Capacity __________ Overflow ______________________________
Location __________________________________________________________
Covered _______________________________ Kind ___________________________

Temperature ---------- °F
Residual chlorine ---------- ppm
Sample ----------

| Average Analysis of ------ samples | |
|---|---|
| B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | *Per cc.* |

What lines discharge into surge tank? ---------- From what units?
---------- gallons per minute for each line ----------
What is this water used for? ----------
Recycle pump size ---------- Capacity ---------- Discharge pressure ----------
Is discharge line cross connected with any other system? ----------
Sketch ---------- Remarks ----------

## DRINKING WATER SYSTEM

Source ----------
Filtered ----------
Treated ----------
Cooled ----------
Temperature ---------- °F.
Residual chlorine ---------- ppm
Pressure ----------
Sample ----------

| Average analysis of ------ samples | |
|---|---|
| B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | *Per cc.* |
| | |
| | |

Give general description of filtering system ----------

Where are drains from filter discharged? ----------

Has this system separate piping with tank and return? ----------
Detail ----------
Cross connected with any other system? ----------

Bleeders ---------- Valved ---------- to where ----------
Sketch ---------- Remarks ----------

## WELL WATER SYSTEM

Location of well ----------
Depth ---------- Size and kind of casing ----------
Condition ---------- Type of pump ---------- Capacity ----------
Discharge pressure ---------- Purpose for which water is used ----------

Filtered ----------
Treated ----------
Cooled ----------

| Average analysis of ------ samples | |
|---|---|
| B. coli in 100 cc. | Bact. Ct. Agar 37° C., 24 hours |
| | *Per cc.* |
| | |

Cross connected with any other system ----------
Detail ----------
Sketch ---------- Remarks ----------

## FIRE AND SPRINKLER SYSTEMS

Source ---------- Separate tank ---------- Capacity ---------- Location ----------
Fire pump capacity ---------- Discharge pressure ----------
Suction pressure ------ Is this system cross connected with any other system ------
Are there any bleeder lines ------ Valved ------ to where ----------
Sketch ---------- Remarks ----------

## COOLERS AND CONDENSERS

Refrigerators ---------- Water required ---------- gpm. Source ----------
Temperature on ----------° F. off ----------° F.
Size inlet -------------- outlet ---------- Discharge to ------------------
Discharge bypass to ----------------------------------------------------
Detail ----------------------------------------------------------------

## SEWERS AND SEWERAGE

*Outside building line*

Size street sewer -------- Size house sewer -------- Material -------------
Gradient house sewer -------- Vents -------- Size ----------------------
Location -------------------------------------------------------------
Condition ------------------------------------------------------------
Remarks -------------------------------------------------------------

*Inside building—house drains*

1. Location ------------------------------------------------------------
   Material -------- Size -------- Condition ----------------------------
   Number of stacks served -------- Total units on stacks ------------------
   Total units on drain -------- Probable slope -----------------------------
   Are there any traps? -------- Cleanouts -------- Vents ---------------
   Is drain cross connected with any other system? --------------------------
   Details and sketch ---------------------------------------------------
   Remarks -------------------------------------------------------------
2. Location ------------------------------------------------------------
   Material -------- Size ---------- Condition ----------------------------
   Number of stacks served ------ Total units on stacks --------------------
   Total units on drain -------- Probable slope -----------------------------
   Are there any traps? -------- Cleanouts -------- Vents ----------------
   Is drain cross connected with any other system? --------------------------
   Details and sketch ---------------------------------------------------
   Remarks -------------------------------------------------------------
3. Location ------------------------------------------------------------
   Materials -------- Size -------- Condition ----------------------------
   Number of stacks served ------ Total units on stacks --------------------
   Total units on drain -------- Probable slope -----------------------------
   Are there any traps? -------- Cleanouts -------- Vents ----------------
   Is drain cross connected with any other system? --------------------------
   Details and sketch ---------------------------------------------------
   Are any house drains over or near food handling? -------------------------
   ----------------------------------------------------------------------

## STACKS

| | Rooms served | Size | Material and condition | Total fixtures |
|---|---|---|---|---|
| 1. | | | | |
| 2. | | | | |
| 3. | | | | |
| 4. | | | | |
| 5. | | | | |
| 6. | | | | |
| 7. | | | | |
| 8. | | | | |
| 9. | | | | |
| 10. | | | | |

What lines or units drain into stacks other than fixtures? ------------------
----------------------------------------------------------------------

List downspouts which are separate from stacks:
Size ---------- Area served ---------- sq. ft. Condition --------------
Size ---------- Area served ---------- sq. ft. Condition --------------
Size ---------- Area served ---------- sq. ft. Condition --------------
Size ---------- Area served ---------- sq. ft. Condition --------------

Are stacks in open shafts? ____________
Hydraulic test—Stack ________ No. of fixtures used ________ gpm.
Hydraulic test—Stack ________ No. of fixtures used ________ gpm.
Hydraulic test—Stack ________ No. of fixtures used ________ gpm.
Hydraulic test—Stack ________ No. of fixtures used ________ gpm.
Remarks on tests—Data ____________
____________
____________
Sketch ________ Remarks ____________
____________
____________

### VENTS AND REVENTS

Condition ________ Open through roof ____________
Are shafts open to atmosphere ________ Protected ____________
Remarks ____________

### DRAINS

Units served:
Floor ________ Discharge to ________
Ice box ________ Discharge to ________
Water-cooled bearings ________ Discharge to ________
Hot water heater ________ Discharge to ________
Flexible hose ________ Discharge to ________
Hydraulic elevator ________ Discharge to ________
Sketch ________ Remarks ____________
____________

### EJECTORS AND SUMPS

Location ____________
Type and kind of ejector ____________
Type and kind of sump pump ____________
Purpose used ____________
Size discharge line ____________
Condition ____________
Are pumps primed ____________
Detail ________ Remarks ____________
____________

### OTHER DATA

____________
____________
____________
____________

## For Hospitals, Institutions, Etc.

### INSTRUMENT STERILIZERS

| 1. | 2. |
|---|---|
| Make ________ | Make ________ |
| Location of water inlet ________ | Location of water inlet ________ |
| Outlet ________ | Outlet ________ |
| Water bleeder ________ | Water bleeder ________ |
| Vacuum breaker ________ | Vacuum breaker ________ |
| Drain connection protected ________ | Drain connection protected ________ |
| Steam outlet vented ________ | Steam outlet vented ________ |
| Where ________ | Where ________ |

### PRESSURE STEAM STERILIZERS (AUTOCLAVES)

| | |
|---|---|
| Steam outlet protected ________ | Steam outlet protected ________ |
| Drain protected ________ | Drain protected ________ |
| Drip seal ________ | Drip seal ________ |
| If vented, where to? ________ | If vented, where to? ________ |

### WATER STERILIZERS

Water supply inlet------------------- Protection--------------------------
Filter------------------------------- Protection--------------------------
Cooling coil drain------------------- Protection--------------------------
Reservoir drain---------------------- Protection--------------------------

### BEDPAN STERILIZERS

Make ---------- Water or steam inlet location ---------- Protection --------
Type of valve ---------- Flushometer ---------- Vacuum breaker ------------
Location of V. B. on inlet or outlet side ---------- Make ------------------
Approximate area of air vent ---------------------------------------------

### SPECIAL BATHS

Make ---------- Continuous flow ---------- Protection ---------------------
Flush valve protected ---------- Condition --------------------------------

### LABORATORY EQUIPMENT

Aspirators--------------------------- Protected---------------------------
Heaters------------------------------ Protected---------------------------

### AUTOPSY ROOM

Table drain-------------------------- Protected---------------------------
Flush valve protected-----------------------------------------------------

### OTHER DATA

--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------

# APPENDIX B

## INSTRUCTIONS FOR PREPARATION OF PLUMBING INSPECTION REPORTS

### DEPARTMENTAL REPORTS

The general report to the Federal department having jurisdiction over the buildings inspected will deal briefly with the history of the project, its purpose and objective.

This will be followed by general remarks on dangers of cross-connections and back-siphonage. It will call attention to experience gained through the Chicago amebic dysentery outbreak that chlorination alone is insufficient when the water supply is subject to initial contamination at its source or to recontamination through cross-connections and back-siphonage in the distribution systems.

The dangers accompanying improperly located and defective sewers with relation to water distribution systems and food handling establishments will be pointed out. These general remarks will be in sufficient detail to make it unnecessary to specify in the detailed plumbing report why certain cross-connections, submerged orifices in lavatories, bathtubs, sterilizers, etc., and simple flushometers are to be viewed with alarm.

Following the general remarks in the departmental report will be the map showing the group locations of all Federal buildings in the city, with a list of the groups under the jurisdiction of this particular department.

After this the group reports will follow in numerical order, such group report having a title page showing the number, name, and address of the group and will be separated from other groups by a colored onion skin sheet.

A general summary will follow. This will be a summation of all of the corrections which are recommended for each group under the jurisdiction of this department.

### GROUP REPORTS

*Building list.*—Following the title page of the Group Report as mentioned under Departmental Reports, when the group consists of more than one building, there will follow a list of buildings and structures in the group. All buildings listed having no plumbing will be

indicated by an asterisk following the unit number. This list may or may not be a part of the group map.

*Group map.*—The Group Map will show the relative location of each building or structure in the group. Where it is necessary to illustrate certain deficiencies or violations outside of the building, in the water and sewer lines, the latter will be shown on the Group Maps.

*Engineering survey.*—If the group involves more than one building, having a common source of water supply, sewerage or sewage disposal system, there should be inserted here a description of the water supply, its source and method of distribution; and of the sewerage system, including the final treatment and disposal of the sewage, when this disposal is other than through the city sewers.

If the group consists of only one building, the general information regarding source of water supply and sewage disposal may be included under Building Report described hereafter. The individual building reports should follow one another in numerical order as they appear on the building list; excluding these which are marked as having no plumbing.

*Group summary.*—Following the Building Reports there should be a group summary of corrections recommended for each building which will show the total number of corrections of the group.

### BUILDING REPORT

In making field inspections the detail survey blanks should be frequently consulted. Each question presented may have some special use in locating defects and making corrections, and should be carefully weighed as to its importance in connection with the survey of the building under consideration.

Page 1 on the building report will follow the general summary sheet used on the survey blanks except that irrelevant matter will be excluded. The group and unit numbers will be shown in the upper right-hand corner of the sheet. The name of the building, address, use, description, and age of building will be given, and the chief of party and sanitary engineers responsible for making the inspections will also be shown.

The date will show the day of beginning and the day of completion, marking the period covered by the inspection.

A summary will then be given of all deficiencies in the building, listed by numbers only. The classifications of deficiencies as given in the original survey blanks will be maintained, namely, cross-connections, submerged supplies, defective plumbing, faulty drinking fountains, and tanks. No attempt will be made in this summary to describe any deficiency except to show that one exists; the later

sections of the report will include all of the details. Ice boxes, autoclaves, and other equipment having no water connection, which are directly connected to vent or waste lines of the sewer system, will be listed under miscellaneous defective plumbing.

When the plumbing in the building is limited and has no defects or only has a limited number a single sheet may be all that is necessary for a complete report. The data on water supply and the sewerage system for the group must be contained in the general information for the group and no repetition will be necessary here.

In large buildings the second page of the building report will begin with a full description of the water supply and sewerage systems.

A description of the water supply should include the source, number and sizes of meters, size of intake lines, and the general method of supplying water to the building. For example, if the entire building is under city pressure, this should be stated, and if a portion of the building is under city pressure and booster pumps are used for maintaining service to other portions of the building, this should be described. The description should give a clear picture of the method of distributing water to all floors of the building.

If there is a separate drinking-water system it should be described giving its relation to the cold-water system mentioned above.

A general description should be given of the hot-water system and its source.

This should be followed by a description of the fire and sprinkling system, giving the source of water, and its connection with other water services.

If air-conditioning apparatus is in use describe it and its relation to the water and sewer systems. The same applies to condenser and cooling systems.

Include in the report the relationship of roof drains and sanitary sewerage. If the two are combined point out the place of convergence and the adequacy of the outlet of the combined system. Include what can be learned of troubles encountered during heavy rainstorms, backing up of sewers, etc.

A description of the sewer system will also include all pumps, ejectors, etc., used to facilitate the prompt disposal of sewage and storm drainage.

This general description of the various water and sewer systems will be followed with a complete layout of the basement service piping. This includes hot and cold water, ice water, and sewerage. Fire lines need not be included unless they are supplied with water from a different source and are cross-connected with the approved house supply. Pipe sizes and valves should be shown on all sketches.

Usually the entrance of water lines and discharge of sewers is through the basement and, therefore, this should give a good general picture of the systems involved.

The basement sketch should show the services on all risers so that detailed sketches of cross-connections on upper floors may be identified with certain lines. It will thus be unnecessary to show an entire line where there is probably only one faulty piece of apparatus on it. The risers, water and sewage, can be numbered and the description of the services, by floors, can be shown on the sketch, or on an accompanying sheet.

Drawings and sketches on the final report will be of the cabinet style rather than isometric; using horizontal, vertical, and 45° lines. The legend will be as follows:

1. Cold water lines will be shown in solid black.
2. Ice water lines will be shown in solid black with I. W. inserted in the lines at convenient points where this will not detract from the clarity of the drawing.
3. Fire lines will be shown in solid black with a small F superimposed at short intervals, when the course of the water is the same as that in cold water piping.
4. When an auxiliary supply is used to service the fire lines they will be shown in red with a small F superimposed.
5. Hot water lines will be shown by a long dash and two short dashes, in green.
6. Supplementary water supplies will be shown by a long dash with three small dashes, in orange.
7. Vent lines will be shown with a long dash and dot, in blue.
8. Sewer lines will be shown with long dashes, in red.
9. Storm drainage lines will be shown with long dashes, in brown.

Field parties showing piping under 5, 6, 7, 8 and 9 in color will use solid lines only.

If water distribution lines and house drains are on different floors drawings should be made of each.

When it is impossible to trace the water and sewer lines, because of concealed piping, their probable location should be shown on the sketches with broken lines. Sometimes original plans may be secured for use as a guide in locating concealed piping but these should not be used as a substitute for visual inspection where the latter is possible. Information from this source must be shown with broken lines indicating that a visual inspection was not possible.

The primary purpose of this survey is to locate actual and potential public health hazards in the plumbing systems in the buildings and the reservations inspected, and to recommend such changes as are necessary to eliminate them. All contaminating influences, through

cross-connections, back-siphonage, air pollution, improper location of sewer lines, or other factors, which may affect the water supply, food supplies, or sterilizing fixtures shall be considered.

In buildings which have been in use for a considerable length of time, where no difficulty has been experienced with stoppage, overflows, and leakage and no defects measured by the previous paragraph are apparent to the inspection party, it will be assumed that stacks, vents, and soil lines are of ample size and are functioning properly. The sketches of sewer lines under such circumstances will be confined to the basement or lower floor collection system showing the location of risers and a list of the services connected thereto.

Improperly located sewers should always be shown by sketches. The determination of such are the responsibility of the chiefs of party as no general rule applicable to all conditions can be stated.

All actual or potential cross-connections between lines should be well illustrated by sketches in detail showing the undesirable features, and if possible an accompanying illustration showing a suitable correction. Special fixtures should be illustrated by sketches, photographs, or both, showing actual or potential hazards to public health.

The common lavatories, bathtubs, laundry tubs, ordinary sinks, etc., should all be listed, giving their location in the building (by room number when possible), and the deficiencies, if any, with their connections. Toilets and urinals will be listed separately, giving location in the building, make and type of bowl or description of same; low or high tank, or flushometer; check valve and vacuum breaker (make and type), with corrections.

A Building Report will close with a summation of all corrections recommended, including cross-connections, disapproved fixtures or defective plumbing.

## SUPPLEMENT TO INSTRUCTIONS FOR PREPARATION OF PLUMBING INSPECTION REPORTS

All risers will be numbered. The number being preceded by the letter denoting the type of riser. Example:

C = Cold water.
H = Hot water.
F = Fire line.
S = Soil stack.
L = Rain leader.
I. W. = Ice water.
V = Vent.

The hot and cold pipes that feed the same fixtures will have the same number wherever possible.

Field sketches will be made of risers that feed a number of fixtures. This will not however exclude these particular risers from the list giving all risers and tabulations of all fixtures by floors on each riser. These field sketches will be for use in determining where to take water samples for analysis. In most instances, they will not be redrawn by the office draftsmen.

It is desired that the final office drawings have all piping on one sheet, therefore it is well for the field parties to keep this in mind so that their cold, hot, sewer, etc. sketches may easily be assembled in the office. The direction of north should be indicated on each sketch.

Basement plans redrawn by the office force will be checked in the office by the individual chiefs of party to see that they are in perfect agreement with their field sketches. The plans will then be checked by the office engineer.

Detailed sketches of cross-connections etc. will first be checked by the office engineer and drawn up by the office draftsmen only after an O. K. by the office engineer. It is believed that this procedure will give the office draftsmen the least amount of redrawing.

The office engineer is to go over all sketches and reports submitted and note missing data, details needing clarification, errors, disagreements, etc. These points will be taken up with and straightened out by the chiefs of party.

The office engineer will then make up the final building report.

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